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AN ANALYSIS OF THE NAVY'S SCIENCE AND TECHNOLOGY (S&T) BUDGET

by

John A. Zangardi
June 1994

Principal Advisor: William R. Gates

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This thesis examines the importance of the Navy's Science and Technology (S&T) budget. The relevance and value of the budget are addressed. The composition and size of the Navy's S&T budget between 1984 and 1994 are evaluated as a share of the Department of Defense (DoD) and Navy Research, Development, Test, and Evaluation (RDT&E) budgets. The Navy S&T budget is examined from the presidential request through appropriations over a ten year period. There is an analysis of Naval Technology Transfer Programs and an examination of Advanced Technology Demonstrations (ATDs) and Enhanced Technology Demonstrations (ETDs). Five major conclusions are drawn. First, the period between 1984 and 1987 generally saw DoD RDT&E, Navy RDT&E, and Navy S&T generally increase. Second, for the period 1988 and 1994, DoD and Navy RDT&E funding generally decreased while Navy S&T generally increased. Third, for the 1989 through 1993 period there was significantly more conflict between Congress and the executive branch over Navy S&T funding levels. Fourth, technology transfer programs represent an increasing constraint on S&T procurement. Fifth, ATDs and ETDs have generally increased their share of the Navy Advanced Technology Development account between 1991 and 1994.

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AN ANALYSIS OF THE NAVY'S SCIENCE AND TECHNOLOGY (S&T) BUDGET

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ABSTRACT

This thesis examines the importance of the Navy's Science and Technology (S&T) budget. The relevance and value of the budget are addressed. The composition and size of the Navy's S&T budget between 1984 and 1994 are evaluated as a share of the Department of Defense (DoD) and Navy Research, Development, Test, and Evaluation (RDT&E) budgets. The Navy S&T budget is examined from the presidential request through appropriations over a ten year period. There is an analysis of Naval Technology Transfer Programs and an examination of Advanced Technology Demonstrations (ATDs) and Enhanced Technology Demonstrations (ETDs). Five major conclusions are drawn. First, the period between 1984 and 1987 generally saw DoD RDT&E, Navy RDT&E, and Navy S&T generally increase. Second, for the period 1988 and 1994, DoD and Navy RDT&E funding generally decreased while Navy S&T generally increased. Third, for the 1989 through 1993 period there was significantly more conflict between Congress and the executive branch over Navy S&T funding levels. Fourth, technology transfer programs represent an increasing constraint on S&T procurement. Fifth, ATDs and ETDs have generally increased their share of the Navy Advanced Technology Development account between 1991 and 1994.

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I. INTRODUCTION

This chapter describes this thesis' research questions, scope, methodology, and chapter organization.

A. OBJECTIVES

This thesis identifies trends occurring within the Navy's Science and Technology (S&T) budget. These trends will be explored by comparing the President's budget submission and the congressional response. The congressional response will be examined at two levels, authorizations and appropriations. This information is relevant to theories concerning congressional incentives and focuses on an area of the Department of Defense (DoD) budget that has received little attention.

Investment in S&T is essential to build a prosperous economy and maintain national security. Each armed service has a Research, Development, Test, and Evaluation (RDT&E) budget. The RDT&E process moves technology from basic research to acquisition. Each stage in this process emphasizes a different aspect in technology development. The S&T category involves investigating new technologies that have a variety of applications. When a specific application is in sight, S&T shifts the emphasis to obtaining information about the design and engineering of a new system.

Congress has tried to alter the way research is purchased so the economy's civilian segment can benefit from military research dollars. Two examples will be presented. First, in 1982 Congress passed the Small Business Innovative Research (SBIR) Act to encourage small businesses to become a principal technological innovation source. The Act attempted to increase small business participation in federal research and development. Second, the 1992 Defense Conversion, Reinvestment, and Transition Act by means of the Technology Reinvestment Project (TRP) aimed at breaking down barriers preventing the flow of military technology to commercial markets.

DoD is attempting to take advantage of high technology. These efforts to develop high technology demonstrations should improve military capabilities while enhancing the industrial base. The Advanced Technology Demonstrations (ATDs) and Enhanced Technology Demonstrations (ETDs), are prototyping systems to test new concepts. After identifying new high leverage technology that will provide a definitive advantage for the armed forces, the U.S. will build a demonstration system to test the concept. The Advanced Concept Technology Demonstration (ACTD) program is designed to rapidly transition maturing technologies into improved military operational capability.

B. THE RESEARCH QUESTIONS

The following research questions will be addressed:

1. During the past decade, the Navy's S&T budget has undergone significant changes. What S&T funding trends have become apparent? An anticipated trend is that budget requests have exceeded authorizations and appropriations.

2. Is there a significant difference between funding requests for Navy S&T and congressional authorizations and appropriations for Navy S&T?

3. When considering the degree of congressional intervention on the budget process for Navy S&T, did Congress adhere to their traditional roles for the authorization and appropriation processes?

4. Do congressionally mandated technology transfer programs such as SBIR or TRP restrict military procurement decisions?

5. What is the purpose of taking advantage of high technology by refining of the technology development integration process? These efforts include SBIR, Navy Dual-Use Technology Programs, ACTDs, ATDs, and ETDs.

C. SCOPE

The RDT&E budget includes S&T. Normally, RDT&E, procurement, and military construction are referred to as the investment budget. In this thesis, only RDT&E will be examined. The changes between individual S&T accounts relative to RDT&E are important for examining investment policy within congressional policy constraints. The thesis will address the Navy's S&T budget as a share of the total DoD and Navy RDT&E budget. To provide perspective, ten years of funding levels will be contrasted.

This thesis will examine Congressional fiscal oversight, including changes to the executive branch's proposed funding for S&T during the legislative budget process.

This thesis will also examine the SBIR program's effect on the Navy's overall flexibility in deciding where to procure research.

D. METHODOLOGY

This thesis will examine congressional changes to the executive branch's budget request for Navy S&T and DoD RDT&E. Data from the Naval Comptroller's Office and reports from the conference committees for authorization and appropriation are used to explore and contrast ten years of budgetary adjustments to the President's budget submission. This information answers various questions regarding fiscal scrutiny and S&T budgetary control.

The analysis of S&T funding covers the period from FY 84 to FY 94. This period reflects the budgets of three administrations: Reagan, Bush, and Clinton. Constant dollars are used for the evaluation process.

E. ORGANIZATION OF STUDY

Chapter II, "The Importance of the S&T Budget," will provide background concerning S&T. Congressional interest in and impact on the S&T budget, the importance of the DoD S&T budget, and technological base preservation are addressed.

Chapter III, "Defense Science and Technology Budget," will address current defense budget requests developed from 1984 to 1994. This chapter will also contrast these budget requests with Congressional authorizations and appropriations. All

S&T accounts will be examined separately. The 6.1, 6.2, and 6.3a accounts will be compared to Navy RDT&E and DoD RDT&E to indicate their relative movements.

Chapter IV, "The Nature of Congressional Intervention in S&T," will look at the congressional changes and alterations that have been made to the Navy S&T budget request over the past ten years. The concept of technology transfer will be discussed. This chapter will also discuss the SBIR program, Navy Dual-Use Program acquisition, and ACTD. SBIR's and TRP's impact on the Navy's budget will be examined.

Chapter V, "The Significance of Advanced Prototypes," will examine the implication of advanced prototypes on the budget, specifically the 6.3a account. There will be an analysis of Navy ADTs and ETDs funding.

Chapter IV, "Conclusions," will summarize the analysis and findings from the previous chapters. Trends will be identified, implications drawn, and suggestions for further study offered.

II. THE IMPORTANCE OF THE S&T BUDGET

A. INTRODUCTION

Since the dawn of the Cold War, the United States has invested in S&T to support an arms race with the former Soviet Union. With the collapse of the USSR, the U.S. is now the predominant global power. The clarity of American security objectives owed much to the singularity of the Soviet threat in a bi-polar world. Global technology-based competition has supplanted the arms race and could be the greatest threat to U.S. security. Political and military alliances are no longer as simple as democracy versus communism or free market versus state-run enterprise. The national security environment that the U.S. is now entering is less defined and more unstable, with many widespread threats.

Regional powers pose a relatively larger menace to U.S. national interests and security. Potential adversaries that obtain sophisticated weapons through technology proliferation and foreign arms sales constitute a growing threat. Deadly weapons are already finding their way into widely dispersed and unpredictable hands. Potential enemies may obtain advanced commercial technology for military applications. The U.S. technological advantage on the battlefield could erode. These factors will demand flexible and creative responses from the U.S. defense industrial base.

In the 1992 National Military Strategy of the U.S., then Chairman of the Joint Chiefs of Staff, General Colin L. Powell, proposed that the "United States must continue to offset quantitative advantages, to minimize risk to U.S. forces, and to enhance the potential for swift, decisive termination of conflict." The general also noted that technological superiority is a key element of deterrence and that it enhances combat effectiveness and reduces loss of personnel and equipment in war. [Ref. 1:p. 10] In light of a changing world scenario, a review of S&T is warranted.

B. BACKGROUND

Former Secretary of Defense Robert McNamara put in place a DoD R&D process composed of several budget categories in order of increasing technological maturity. This sequential transition of R&D investment starts at Basic Research (6.1), Exploratory Development (6.2), Advanced Technology Development (6.3a), Advanced Development (6.3b), Full-Scale Development (6.4), and finally ends in procurement. This process was created to bring financial responsibility to an enormous and complex acquisition process. This process can best be described as a pipeline through which systems move. Program categories 6.1 through 6.4 represent DoD's RDT&E budget. Program categories 6.1, 6.2, and 6.3a constitute the S&T portion of the DoD budget. [Ref. 2:pp. 48-52] Program categories 6.1 and 6.2 are referred to as the Technology Base. [Ref. 3:pp. N-1 & N-2]

To illustrate the differences between categories, Basic Research deals with general properties such as material sciences, aerodynamics, or chemical thermodynamics. Exploratory Development involves lab bench tests of particular components, such as a compressor or a turbine. Advanced Technology Development demonstrates components working together. Core engine components operating with an application, e.g., an aircraft or tank, is an example of Advanced Development. Full-Scale Engineering development demonstrates the product prototype and associated manufacturing processes and controls. [Ref. 2:pp. 48-52]

In the mid-1960's, policies were established to manage new weapon systems acquisition. They applied visible cost accounting and cost performance evaluations to the DoD weapon system management process. Under this policy, technology is carried by the acquisition process. Each system's cost includes the prorated costs of research and development. These R&D costs are allocated to weapon systems by defense firms as a part of those systems' production costs. This was a natural consequence of the cost-effectiveness criteria and policies developed during the McNamara era. [Ref. 4:p. 86]

As a rough rule, universities tend to concentrate on Basic Research, service laboratories on Applied Research, and industry on Development and Engineering. The research phase involves investigating new technologies that might have several applications. When a specific application is identified, e.g., a weapon system, significant development and engineering work is still required to incorporate the technology. [Ref. 2:p. 50]

Exploratory and Advanced Development provide data about the design and engineering of a new system. Virtually all engineering and development are performed by the private sector. These contractors have invaluable experience in applying knowledge to the production process. [Ref. 2:p. 51] The information provided in stages 6.2 and 6.3 allows managers to make production decisions concerning a system with reasonable confidence about schedule, performance, and cost. [Ref. 2:p. 50] The purpose of 6.3a, 6.3b, and 6.4 is to advance technology to a maturity level where it can be placed into service. [Ref. 4:p. 90]

C. CONGRESSIONAL INTEREST AND IMPACT

DoD's RDT&E budget invites congressional interest and intervention for two reasons: the sheer size of the DoD budget for RDT&E and the political sensitivity concerning science and technology policy. For FY 94, DoD will spend $39 billion on RDT&E; $14 billion of which will be spent on S&T. [Ref. 3:p. II] That is an enormous amount of resources. Furthermore, these defense programs are discretionary dollars. It is relatively easy to modify the president's S&T budget proposal, in part because the budget submission does not explicitly state S&T priorities. Congressional committees normally do not consider the S&T budget for all federal agencies at once. Although Congress does not specifically authorize or appropriate based upon broad categories such as total U.S. R&D funding, it is aware of the totals for various categories, such as Army or Navy 6.1 funding, and may attempt to balance these categories. [Ref. 5:pp. 8-12]

Second, defense RDT&E spending is a politically salient issue that generates much debate. [Ref. 5:pp. 8-12] Throughout our country's recent history, technology has been seen as the driving force behind the nation's economic growth. Since the 1970s, it increasingly seems as if U.S. manufacturing has been losing its competitive edge. The U.S. lead in many industries has been lost to other industrialized nations. Those who support an industrial policy cite these declining industries as ripe for government support. Industrial policy advocates observe that most other industrialized nations have instituted government policies to support industrial sectors. They assert that this support has undermined U.S. international competitiveness in some technologies. Opponents of industrial policy question whether a centralized industrial policy is really effective. They fear that such national planning would represent unwarranted government intrusion into the private sector and adversely affect our industrial competitiveness.

The defense RDT&E budget represents both investment for defense technology and a potential contribution to the civilian technological effort. Faced with fewer federal funds to support civilian S&T efforts, the DoD S&T budget represents a lucrative vehicle for that purpose. Military research efforts that also have civilian applications are commonly referred to as dual-use technologies. [Ref. 2:pp. 35-40]

Within DoD's RDT&E budget, S&T draws particular emphasis. This interest is generated by three factors. First, an investment in S&T is perceived as essential for addressing national needs and objectives. Second, S&T breakthroughs and developments in many areas of science and engineering are likely to yield widespread economic and other benefits. Many in Congress believe that programs such as SBIR or TRP facilitate this technology transfer. Third, there are specific national emergencies that require support for S&T investments aimed at solutions. An example would be developing technology to aid in environmental cleanup. [Ref. 6:pp. 20-25]

In spite of the interest S&T generates, the realities of the federal budget deficit constrain the DoD S&T budget. As funding decreases, fewer funds are available for defense related S&T. Using DoD S&T funds for non-defense priorities would further compromise defense related S&T. In times of reduced weapon system procurement, it is unreasonable to expect private industry to help offset these decreases by independently investing in unique military S&T for DoD's long term benefit. The DoD S&T base must be viewed as vital. The long term investment in human resources and facilities required to establish a defense S&T capability will be difficult to reconstitute at a later time. [Ref. 7:p. 23]

D. THE IMPORTANCE OF THE DoD S&T BUDGET

1. Critical Technologies

In addition to decreasing defense budgets, another trend affecting the DTIB is the growing importance of technology to national power. The increasing technological capability and economic power of Western European nations, Japan, and other rapidly growing Asian nations challenge the technological hegemony of the United States. Although America is still dominant in many areas, there is an increasing risk that this nation may lose its leadership position in some technologies essential for national security and economic prosperity.

These key or critical defense technologies are the most important for ensuring the long-term qualitative superiority of U.S. weapon systems. [Ref. 17:p. 2] Despite a growing concern about critical technology, the U.S. Armed Forces no longer dominate the industrial development of most high technology defense products. Continually increasing commercial demand for these high technology products have made DoD a less important customer. Additionally, defense acquisition practices for advanced product and process technologies has been surpassed by commercial practice. DoD acquisition practices have not evolved to take advantage of technological innovations while commercial concerns have integrated innovations such as just in time inventories. The result for DoD is that it generally pays more for less advanced products. [Ref. 18:pp. 22-24]

While DoD has long had an active S&T program, the specific focus on critical technologies is a relatively recent development. The U.S. has traditionally led the world in advanced technology R&D and continues to do so. Nevertheless, U.S. defense and commercial producers have often lost out to foreign competitors in capitalizing on U.S. technological developments with commercially viable products and fielded weapon capabilities. A 1990 Department of Commerce report suggests that, if current trends continue through the year 2000, the U.S. could lag behind Japan in most emerging technologies and trail the Western European Community in several. [Ref. 17:p. 15]

Nevertheless, many maintain that current defense procurement policies do not foster a healthy defense industry R&D capability in a time of reduced weapon system acquisition. Specifically targeting these limited defense dollars to maintain a viable DTIB is one goal of the Clinton Administration. The ACTD program is a Clinton Administration initiative supporting the defense industrial base. Current military programs in the 6.3a account, such as ATDs and ETDs, are efforts to target defense dollars to maintain a strong DTIB. Despite this effort, many critical defense contractors might fail or leave the defense industry.

2. Dual-Use Technologies

There has been a move toward augmenting federal support for technologies that are deemed critical. Lists of critical civilian and defense technologies display significant overlap. This suggests to some that government funding should support dual-use technology development. Dual-use technologies provide an opportunity for defense firms to market technologies to the commercial sector. This could breath new life into these struggling defense industries. [Ref. 19:pp. 296-314]

In FY 90, DoD laboratories accounted for over 30 percent of DoD's federal funds for basic research, applied research and exploratory development, and development funding. [Ref. 2:pp. 50-51] Much of the technology developed in federal laboratories has commercial as well as defense applications. This suggests that federal laboratories might work more closely with the private sector. In-house R&D could reflect industry's needs as well as those in government. [Ref. 19:p. 297]

The Advanced Research Projects Agency (ARPA), formerly the Defense Advanced Research Projects Agency (DARPA), has supported high-risk, leading-edge technology development necessary to meet military requirements. ARPA has been successful in stimulating the commercialization of new technologies originally developed for DoD. [Ref. 19:p. 298] Through ARPA, the government is centrally targeting industries and implementing a minimal industrial policy to support defense sector firms.

Mr. Douglas E. Olesen, President and CEO of Battelle Memorial Institute, noted that companies bringing the best technologies to the marketplace the quickest will have a competitive advantage. In his view, that is why investments in technology are among the most critical investments industry is making today. [Ref. 20:p. 210] After Battelle won a contract to run a Department of Energy Laboratory in 1965, it discovered one researcher working on technology that would store digitized music on a disk, to be replayed with a laser. Battelle supported this technology throughout the '70s. It eventually came to market as the compact disc. [Ref. 20:pp. 209-212]

President Clinton argues that the nation must go beyond past debates in which "some thought government alone could do everything and others claimed government could do nothing." Clinton states that the government can aid industry. Government, in this view, can promote dual-use research and promote civilian use of technology developed for military purposes. [Ref. 13:pp. 1-3]

3. The Foreign Threat

While many factors affect the rate of technical progress, the commercialization and diffusion of products and processes have often been cited as a problem in the ability of U.S. industries to compete technologically. The benefits of pure science in the U.S. can be captured by any nation. For the cost of a scientific journal subscription, another nation can obtain the latest technological innovation.

The payoff for basic research is long in coming, the results sometimes not marketable, and the rewards often diffused among many users. Yet, while there is risk that performance of basic research will produce nothing or minimally useful results, it appears there is a significant relationship between the amount of basic research a firm conducts as a portion of its total R&D budget and increases in productivity. Technological advancement permits more efficient ways to produce existing products and to develop new ones. [Ref. 19:p. 296]

In the mid-1970s, U.S. corporations began losing the industrial preeminence they have enjoyed since the end of World War II. The result has been an apparent increase in foreign technology leadership, U.S. purchases from foreign sources, and increased pressure for DoD to restrict its purchases to domestic sources in selected areas. [Ref. 17:pp. 2-3]

DoD has traditionally opposed domestic sourcing requirements except as a last resort. Domestic sourcing requirements can actually worsen DoD's greatest concern: access to cutting edge technology for current and future weapon systems. Most studies indicate that defense acquisition managers typically buy foreign products for superior performance, superior quality or lower cost. [Ref. 17:pp. 3-5] DoD is concerned with a reliable supply of low cost, quality products, regardless of their source.

In the decade ahead, the U.S. defense industry firms will face increasing foreign competition. Many argue that the U.S. government should promote U.S. competitiveness. [Ref. 18:p. 23] The Clinton Administration has affirmed the importance of DoD's S&T budget to aid U.S. firms, while focusing on dual-use technologies and demonstrating developments that many believe will contribute to economic competitiveness. [Ref. 21:p. 1]

Reconstitution as a main facet of U.S. defense strategy is subject to question. The three tiers of the DTIB are prime contractors, subcontractors, and parts suppliers. [Ref. 2:p. 41] Since little is known about the DTIB's lowest tier, the parts suppliers, future reconstitution efforts could be hindered. DoD does not know just how dependent U.S. weapon systems are on foreign made components. [Ref. 18:pp. 22-23]

Congress will ultimately make the choice between domestic and foreign sourcing. This choice involves tradeoffs between national risks and benefits. It is not easy to balance the risks of relying on other nations for critical defense goods against the benefits of access to new technology, regardless of its nationality. Using foreign sources has the side benefit of increasing cooperation with economically strong allies. Congress, in making these choices, may see autonomy as all important in certain vanguard technologies and less important in less sophisticated technical areas. [Ref. 2:pp. 15-17] These decisions will shape and determine the DTIB's composition.

E. PRESERVING THE TECHNOLOGICAL BASE

R&D funding by private firms is expected to decline, since much private sector defense R&D is linked to defense procurement levels. The reduced demand for weapon systems will create a production "trough" over the next several years in certain defense sectors, followed by longer intervals between procurement cycles. As a result, there may be gaps between the end of several current programs and the start of next-generation production. [Ref. 2:pp. 3-4]

Decisions about the DTIB made over the next few years will determine the survival of some U.S. defense firms. In large measure, these decisions will determine the nation's ability to develop and deploy advanced military systems. [Ref. 10:pp. 6-11] Many believe the U.S. government must decide what R&D and production capabilities it should attempt to preserve.

III. DEFENSE SCIENCE AND TECHNOLOGY BUDGET

A. EXPLANATION

This chapter will compare three successive processes of the S&T budget cycle, including budget requests, authorizations, and appropriations. Budget authority within each process will be examined for the period from 1984 to 1994. For each process of the budget cycle, 6.1, 6.2, and 6.3a funding will be contrasted to total DoD and Navy RDT&E.

The first thing Congress needs to know when building a budget is what the executive branch believes is appropriate to fund the federal government's operations. The President is required to submit to Congress in early January the Administration's budget request. Congress considers this budget request and develops the congressional budget resolution by April 15. The authorization legislation follows, and it must be passed in order for a program to exist. The authorization establishes purposes and guidelines for a given activity and usually sets the limit on the amount that can be spent. However, an authorization does not provide the actual dollars for a program. An appropriation must be passed to enable an agency to make spending commitments and obligate dollars. [Ref. 26:pp. C6-C7]

For each budget process, 6.1, 6.2, and 6.3a accounts will be analyzed separately. The analysis will include annual increases or decreases to each account, stated as percentage changes. Each account will also be expressed as a percent of DoD and Navy RDT&E funding. Comparing individual accounts against DoD and Navy RDT&E indicates each account's actual amount relative to overall RDT&E funding.

DoD RDT&E includes all Armed Forces and Defense Agency RDT&E. Before analysis, all data will be converted to 1994 dollars by using a deflator index from the Navy Comptroller's Office.

B. PRESIDENTIAL BUDGET REQUESTS

Table I presents inflation-adjusted budget authority as requested by the President from 1984 until 1994. The amounts presented in Table I will be used for the 6.1, 6.2, and 6.3a budget request analysis. Table I in the appendix presents the budget request figures, not adjusted for inflation, from 1984 to 1994 for DoD RDT&E, Navy RDT&E, 6.1, 6.2, and 6.3a. All of these figures are in thousands of dollars.

1. Basic Research (6.1) Analysis

Figure 1 compares the requested budget authority for 6.1 to the requested DoD RDT&E budget authority. The percentage change in 6.1 are shown for 1985 through 1994. Figures supporting this table can be found in Table II in the appendix.

TABLE I

BUDGET SUBMISSIONS (CONSTANT 1994 DOLLARS)

Year	DoD RDT&E	Navy RDT&E	6.1	6.2	6.3a
1994	38,620,327	9,215,604	433,907	530,119	425,288
1993	39,848,768	8,745,175	486,210	639,152	429,705
1992	42,231,110	8,635,507	444,341	548,570	233,017
1991	41,243,828	9,762,993	434,342	504,910	216,116
1990	44,323,358	11,018,045	437,516	461,009	210,739
1989	44,456,600	10,737,737	415,650	484,547	237,707
1988	53,069,843	12,734,173	462,249	558,564	313,756
1987	52,815,090	13,335,181	489,773	582,211	247,225
1986	51,066,173	14,644,176	483,233	625,931	311,296
1985	45,367,824	13,117,175	467,689	637,867	382,324
1984	40,761,236	11,258,144	446,717	770,036	290,279

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

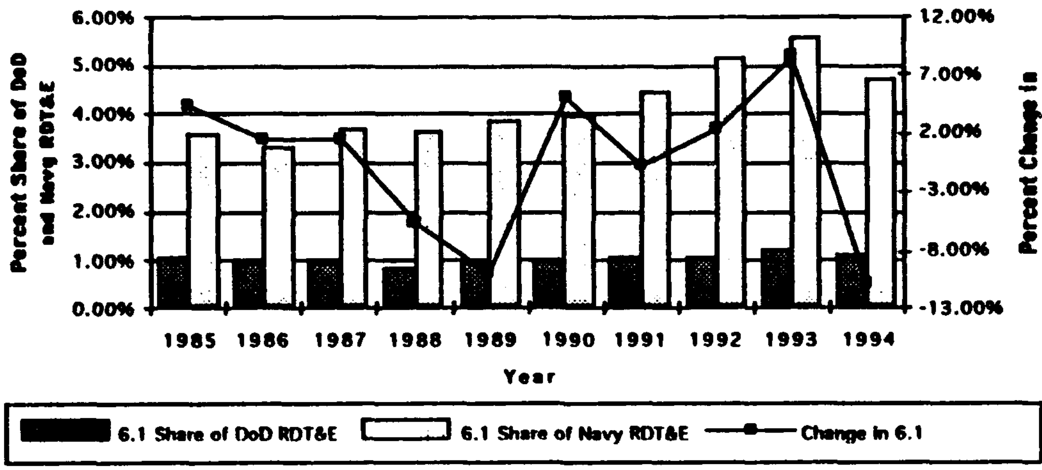

Figure 1. 6.1 Comparison to DoD and Navy RDT&E

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

From 1984 until 1988, 6.1 generally represented a declining share of the DoD and Navy RDT&E budget request. DoD RDT&E emphasis during that period centered on the Strategic Defense Initiative (SDI) and nuclear missiles. Funds for DoD RDT&E expenditures peaked in 1988. After 1988, budget requests for 6.1 represented a larger share of DoD and Navy RDT&E. Basic Research funding grew slightly until 1994, while DoD and Navy RDT&E was decreasing. Through 1993, investment in basic research constituted a growing share of DoD and Navy RDT&E to provide a hedge against technological surprise.

In 1993, basic research investment continued to grow even as DoD RDT&E broadened its investment strategy to include both mission support requirements and areas that have potentially broad private sector applications. According to the 1993 presidential budget submission, government's role is to support generic or enabling technology at the pre-competitive basic research level.

President Clinton's 1994 budget submission asserted that government's role was to invest in dual-use areas where the returns are too far away or the initial investment is too high to attract private sector investment. Despite a nearly 11 percent decline in 6.1 funding levels, the budget request asserted its support for basic research funding with competitive commercial relevance.

2. **Exploratory Development (6.2) Analysis**

Figure 2 compares the requested budget authority for 6.2 to requested DoD and Navy RDT&E budget authority. The percentage change for 6.2 is shown

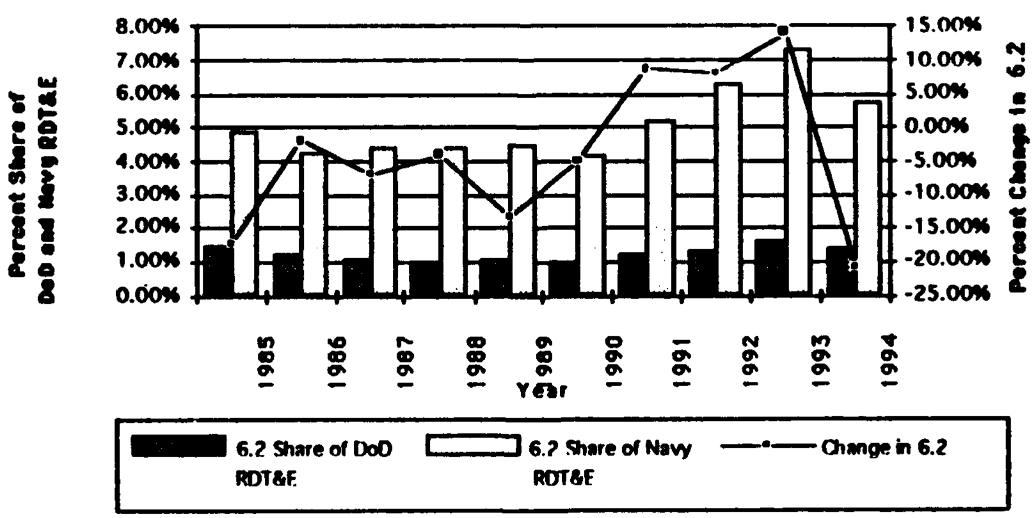

Figure 2. 6.2 Comparison to DoD and Navy RDT&E

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

from 1985 to 1994. Figures supporting this chart can be found in Table III in the appendix.

Following the 6.1 budget request trend, budget requests for 6.2 funding as part of DoD and Navy RDT&E generally decreased from 1984 to 1989, with large decreases in 1985 and 1989. DoD RDT&E budgets steadily increased in real terms through 1988, partly in response to increased research funding for SDI (refer to Table I in this chapter).

From 1984 until 1990, 6.2 experienced a stunning 59 percent drop in funding based on budget requests. By 1993, annual budget requests for 6.2 rose 38 percent compared to 1990 levels. The Bush Administration emphasized technology development efforts and pre-competitive technology later in its term. This helps explain the increase. The 1993 budget request stated that the goal of R&D is to generate new knowledge, train future workers, and act as a catalyst for economic activity. The rate of increase for 6.2 during this period was higher than that of 6.1.

The 1994 budget submission included a 21 percent drop in funding for 6.2. All Navy S&T accounts experienced reductions in the 1994 budget request, with the 6.2 rate of reduction being 50 percent higher than the rate for 6.1. Projections indicate a zero growth mode for S&T through the year 2000.

3. Advanced Technology Development (6.3a) Analysis

Figure 3 compares the requested budget authority for 6.3a to requested DoD and Navy RDT&E budget authority. The percentage change for 6.3a is shown for 1985 to 1994. Figures supporting this chart can be found in Table IV in the appendix.

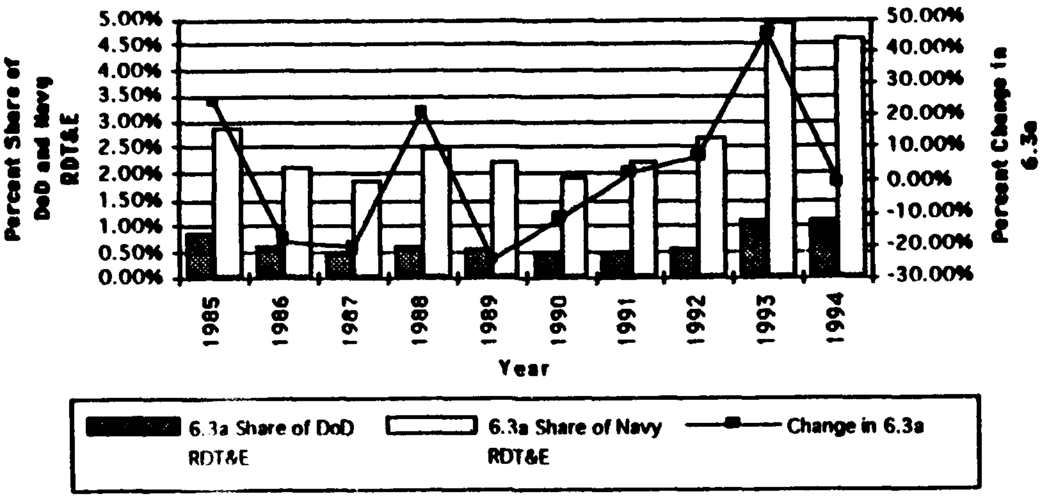

Figure 3. 6.3a Comparison to DoD and Navy RDT&E

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Between 1984 and 1990, the 6.3a budget request declined 27 percent. Unlike funding requested for 6.1 and 6.2, 6.3a did not exhibit a steady decline. Funding swings of approximately 20 percent occurred from year to year. Perhaps 6.3a's volatility can be attributed to its very nature. Items funded by 6.3a represent technology further along in development and closer to actual production. Therefore, it can be more susceptible to changes attributable to production decisions.

Funding requests for 1991 and 1992 increased slightly. The 1993 budget request soared by 46 percent, reflecting the Bush Administration's emphasis on demonstrating the potential of combining different technologies or components. Interest also increased in efforts that support DoD mission requirements and have possible civilian sector applications.

The 1994 budget request remained roughly flat at 1993 levels. Sustained funding for 6.3a is compatible with the Clinton Administration's industrial policy. That policy includes strong support for basic research aimed at projects with a pre-competitive commercial relevance.

4. Budget Request Process Summation

The 6.3a account was more volatile than 6.1 and 6.2 for the 1984 through 1994 period. The most noteworthy trend occurred during the Bush administration. In general, 6.1, 6.2, and 6.3a each accounted for a larger percentage of DoD and Navy RDT&E between 1990 and 1993. It is important to note that the high point for DoD and Navy RDT&E budget requests came in 1986. In spite of decreases in DoD and Navy RDT&E budget requests from 1989 to 1994, S&T accounted for a larger share. This reflected, in part, the decline in funding for SDI and nuclear deterrence. The fact that S&T accounts were growing in relation to DoD and Navy RDT&E budget requests points to the more prominent role S&T played during the Bush Presidency.

In 1994, the first Clinton DoD budget request decreased all S&T funding requests in absolute terms and as shares of both DoD and Navy RDT&E. This may reflect the Clinton administration's emphasis on civilian application research.

C. BUDGET AUTHORIZATIONS

Table II presents the inflation-adjusted budget data as authorized by Congress from 1984 until 1994. The amounts presented in Table II will be used for 6.1, 6.2, and 6.3a authorization analysis. Table V in the appendix presents the nominal authorization figures from 1984 to 1994 for DoD RDT&E, Navy RDT&E, 6.1, 6.2, and 6.3a. Figures in Table II are in thousands of dollars.

TABLE II

BUDGET AUTHORIZATION (CONSTANT 1994 DOLLARS)

Year	DoD RDT&E	Navy RDT&E	6.1	6.2	6.3a
1994	37,885,398	8,736,970	445,407	562,019	419,527
1993	40,671,047	9,224,555	440,009	570,397	362,689
1992	42,213,721	9,098,825	432,361	574,668	244,992
1991	39,081,745	10,196,984	434,342	542,805	255,094
1990	42,845,774	11,365,613	461,687	589,690	242,888
1989	44,238,844	10,932,308	415,650	485,712	239,455
1988	49,176,044	12,074,716	420,283	488,653	313,676
1987	45,617,332	11,706,898	477,676	549,274	197,582
1986	46,137,226	13,138,847	483,233	609,896	279,268
1985	42,825,074	12,559,867	466,855	604,289	261,579
1984	37,565,916	10,483,502	446,717	620,208	264,902

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

1. Basic Research (6.1) Analysis

Figure 4 shows the percentage change for 6.1 for 1985 to 1994. It also compares the authorization for 6.1 to DoD and Navy RDT&E authorizations. Figures supporting this chart can be found in Table VI in the appendix.

Congressional authorizations for 6.1 as a share of DoD and Navy RDT&E generally declined from 1984 through 1988 and increased thereafter. Authorized funding for 6.1 increased by 18 percent between 1984 and 1986, though at a decreasing rate, while DoD RDT&E funding increased by 22 percent and Navy RDT&E funding increased by 25 percent over the same period. Between 1987 and

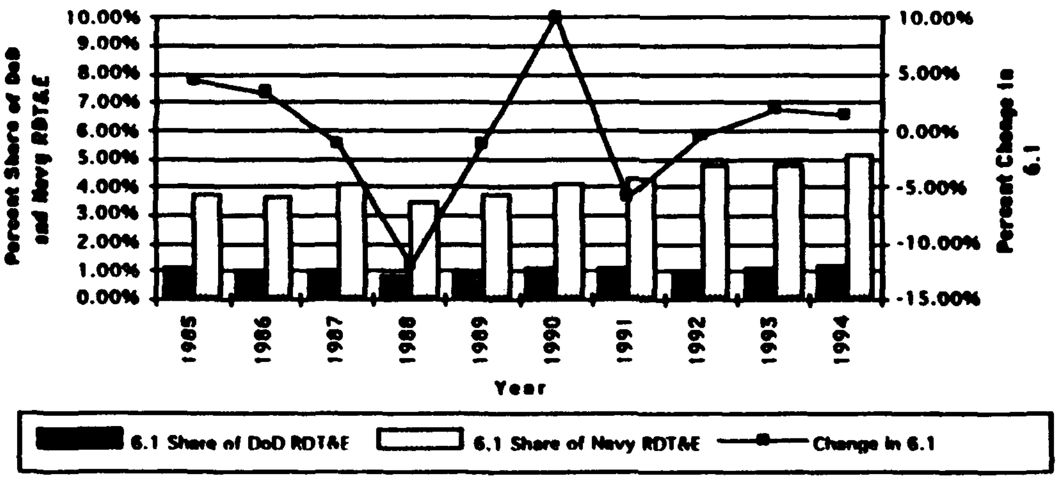

Figure 4. 6.1 Comparison to DoD and Navy RdT&E

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

1989, 6.1 funding decreased by 13 percent while DoD and Navy RDT&E generally declined until 1994. SDI funding reductions began in 1989. After an 11 percent increase in 1990 and a slight decrease of 6 percent in 1991, 6.1 authorizations held roughly constant for the next three years. During the 1989 to 1994 period, 6.1 generally increased its share of DoD and Navy RDT&E.

In 1990, the Senate Armed Services Committee (SASC) chastised the military for a lack clarity in S&T priorities. The committee derided DoD for not having a long term plan and for divergent goals among the branches of the armed forces. The SASC also noted that the DTIB requires the highest priority, particularly because it is closely intertwined with the civilian industrial base. By 1991, the House Armed Services Committee (HASC) wanted DoD to help ensure a vigorous and modern technology pool. Over the next three years, 6.1 authorizations remained roughly constant as Congress recognized the importance of basic technological research.

2. Exploratory Development (6.2) Analysis

Figure 5 compares the authorization for 6.2 to DoD and Navy RDT&E authorizations. The percentage change for 6.2 is shown for 1985 to 1994. Figures supporting this chart can be found in Table VII in the appendix.

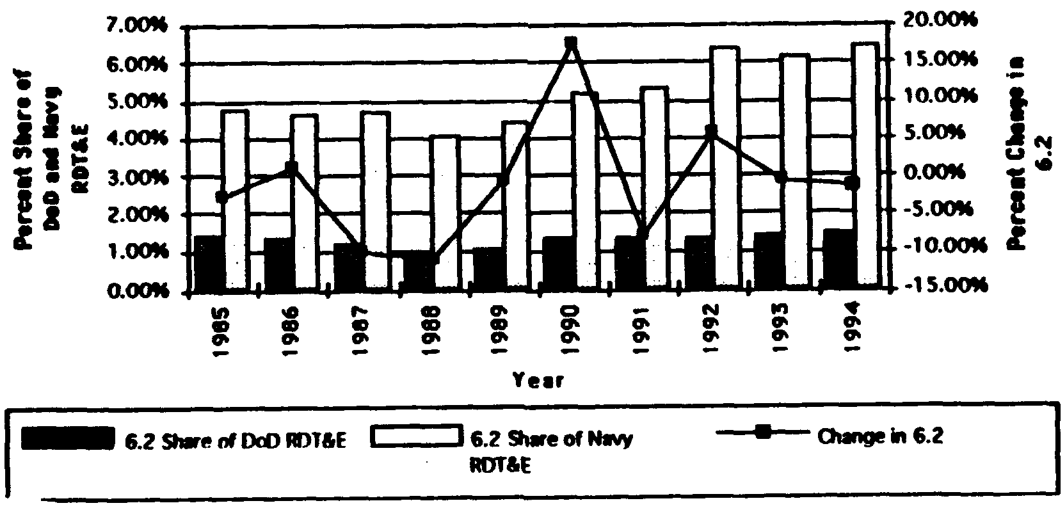

Figure 5. 6.2 Comparison to DoD and Navy RDT&E

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

Authorizations for 6.2 generally declined between 1985 and 1989. As a share of DoD and Navy RDT&E, authorizations for 6.2 bottomed out in 1989. After 1988, the general rate of decrease in DoD and Navy RDT&E funding exceeded that for 6.2. Congress recognized the declines for 6.2 and authorized a 18 percent increase in 1990. Both Congressional chambers stated that our national security relies on superior technology.

Between 1990 and 1994, 6.2 authorizations declined 5 percent. During the same five year period, funding for DoD RDT&E declined 12 percent and Navy RDT&E plummeted 23 percent. Despite a downward trend for defense related RDT&E, 6.2 authorizations declined at a more moderate rate. The HASC stated that it was aware of past downward trends in 6.1 and 6.2 funding and would redirect efforts to emphasize technology base funding. Congress clearly recognized that, to meet its military needs, U.S. critical technology efforts must be supported. By 1994, 6.2 authorizations reached their highest funding level relative to Navy RDT&E over the ten years of data analyzed.

3. Advanced Technology Development (6.3a) Analysis

Figure 6 compares the authorization for 6.3a to DoD and Navy RDT&E authorizations. The percentage change for 6.3a is shown for 1985 to 1994. Figures supporting this chart can be found in Table VIII in the appendix.

Between 1984 and 1994 6.3a authorizations showed an impressive 37 percent increase. 6.3a authorizations did not rise at a uniform rate during the period. Authorizations reached their lowest level in real terms in 1987, falling by 25 percent

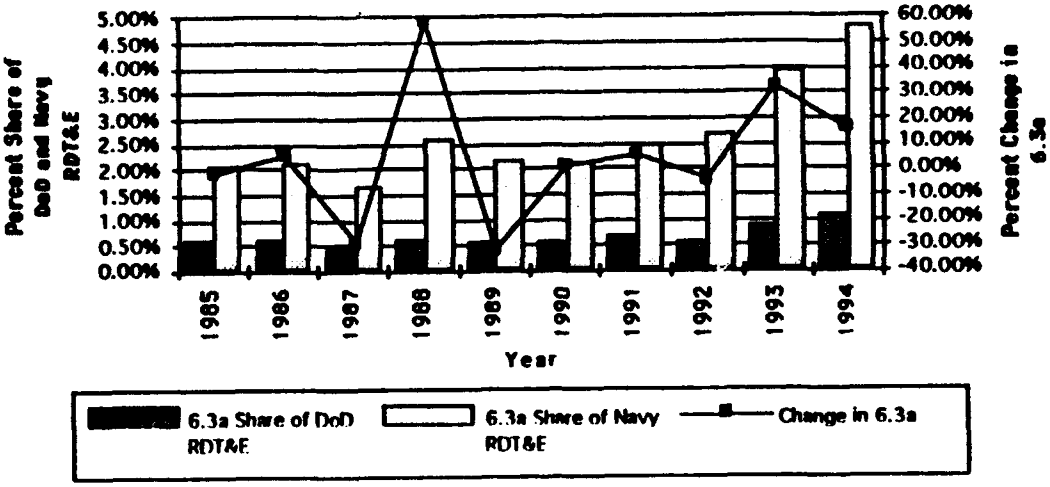

Figure 6. 6.3a Comparison to DoD and Navy RDT&E

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

between 1984 and 1987. By 1988, 6.3a authorizations began to increase, though there were decreases in 1989 and 1992.

By 1987, 6.3a authorization reached their lowest level as a share of DoD and Navy RDT&E. After a relatively large increase in 1988 and a modest increase 1989, 6.3a increased slowly as a share of DoD and Navy RDT&E authorizations until 1987. The increases authorized for 1993 and 1994 were much higher. The increases in 1993 and 1994 reflect the emphasis Congress placed on advanced technology efforts. In 1993, the HASC requested DoD to provide an annual status report of critical sectors, worker skills, technologies, processes, the DTIB and DoD actions to address any shortcomings.

4. Authorization Summation

The most volatile account in the authorization process was 6.3a. 6.3a was also the most volatile account in the budget request process, but the authorization funding swings were more pronounced than the budget request swings. Using inflation adjusted figures, 1989 represented the low point for 6.1 and 6.2 authorizations. In 1989, 6.3a was at its second lowest point for the authorization process. The actual low point for 6.3a authorizations was in 1987. Budget requests for 6.1 were at a low in 1989 and for 6.2 and 6.3a in 1990. This suggests that the authorization process had an impact on the upcoming budget request for S&T during the Bush administration.

S&T authorizations constituted a growing share of Navy RDT&E authorizations after 1988 for 6.1 and 6.2 and after 1989 for 6.3a. From 1989 through 1994, S&T authorizations also increased as a share of DoD RDT&E authorizations. This trend of S&T authorizations preceded a similar trend for S&T budget requests. This authorization trend preceded the budget request trend by two years for 6.1 and 6.2 and one year for 6.3a. Again, this trend points to a heightened emphasis on S&T during the post-Reagan years.

D. BUDGET APPROPRIATION

Table III presents inflation adjusted budget appropriations as approved by Congress from 1984 until 1994. The amounts presented in Table III will be used for 6.1, 6.2, and 6.3a appropriation analysis. Table VIII in the appendix presents the nominal appropriations figures from 1984 to 1994 for DoD RDT&E, Navy RDT&E, 6.1, 6.2, and 6.3a.

1. Basic Research (6.1) Analysis

Figure 7 compares the appropriation for 6.1 to DoD and Navy RDT&E appropriations. The percentage change for 6.1 is shown for 1985 to 1994. Figures supporting this chart can be found in Table IX in the appendix.

Appropriations for 6.1 rose in 1985 and 1986, before gradually declining through 1989. From 1990 until 1993, 6.1 appropriations increased by 14 percent. The 1994 appropriations declined by 9 percent, despite the new administration's focus on S&T and civilian technology.

TABLE III

BUDGET APPROPRIATIONS (CONSTANT 1994 DOLLARS)

Year	DoD RDT&E	Navy RDT&E	6.1	6.2	6.3a
1994	34,946,384	8,365,786	417,407	468,606	437,354
1993	38,975,522	9,168,769	459,196	629,271	443,592
1992	41,286,169	9,018,479	428,672	535,658	243,154
1991	38,676,994	9,785,279	428,435	545,116	245,837
1990	41,421,398	10,954,017	410,308	343,564	195,363
1989	43,624,296	10,931,273	403,999	519,456	219,444
1988	44,689,219	11,575,163	415,169	495,206	275,307
1987	45,099,149	11,747,595	460,597	541,287	166,358
1986	45,940,594	13,085,334	475,475	606,037	248,420
1985	41,632,721	12,244,856	457,480	591,630	295,657
1984	36,722,990	10,401,511	446,717	620,208	236,004

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

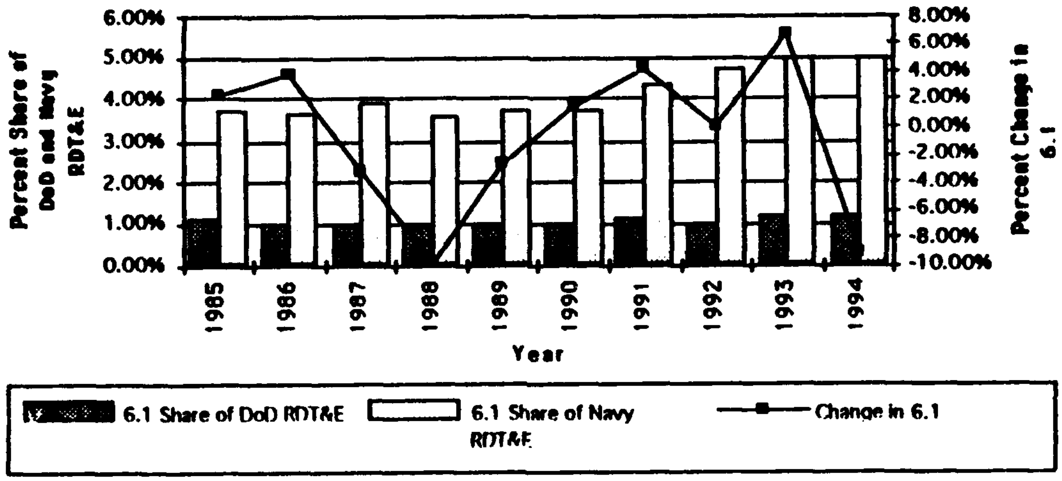

Figure 7. 6.1 Share of DoD and Navy RDT&E

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

Navy 6.1 appropriations as a share of DoD and Navy RDT&E appropriations generally showed a small decline from 1984 to 1989. From 1990 through 1994, 6.1 appropriations increased as a share of DoD and Navy RDT&E appropriations. The share of 6.1 appropriations increased in 1994, even though appropriations for 6.1 decreased. This shows the dramatic decline in overall DoD and Navy RDT&E appropriation levels.

Until 1987, growth in DoD R&D was primarily directed at imperatives for SDI, communications, and space activities. In 1985 the SASC, stated its concern over the share of RDT&E consumed by SDI. The HASC voiced a similar concern about SDI's and nuclear deterrence development's impact on university research funding in 1987. The HASC also stated the importance of university research programs to national security. In the following years, Congressional scrutiny focused on program coordination, prioritization, and cost effectiveness. Congress also stressed the importance of the DTIB.

2. Exploratory Development (6.2) Analysis

Figure 8 compares the appropriation for 6.2 to DoD and Navy RDT&E appropriations. The percentage change for 6.2 is shown for 1985 to 1994. Figures supporting this chart can be found in Table X in the appendix.

No clear yearly trend exists for 6.2 appropriations. In real terms, 6.2 appropriations in 1993 were at roughly the same level as in 1984. Taken on a yearly basis, 6.2 levels varied widely over the entire period. The largest reduction in 6.2 appropriations occurred in 1990, with a cut of 34 percent. That cut reduced the 1990

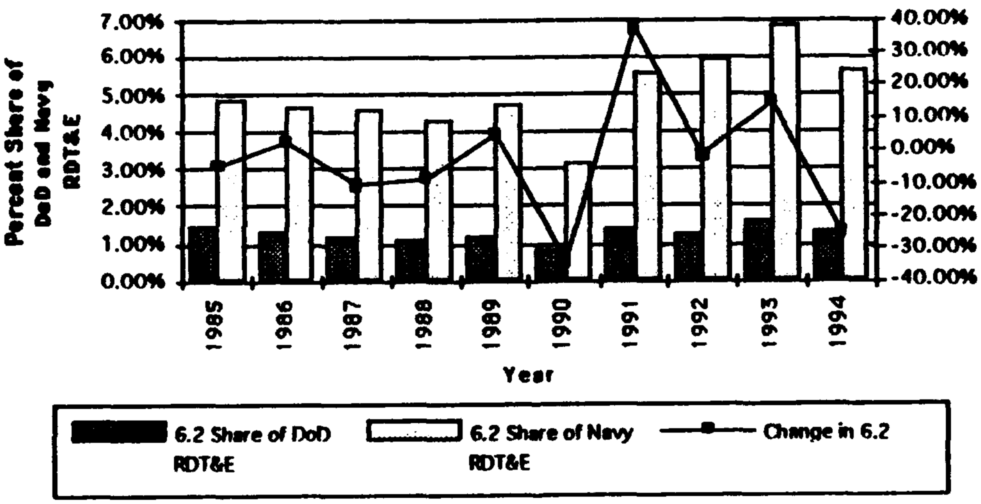

Figure 8. 6.2 Comparison to DoD and Navy RDT&E

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

6.2 appropriation by 45 percent from 1984 levels. The next largest reduction occurred in 1994, as Congress attempted to consolidate research across services, eliminate unnecessary duplication, and increase cost effectiveness.

Between 1984 and 1990, 6.2 appropriations declined by nearly 50 percent as a share of DoD and Navy RDT&E appropriations. 1993 saw 6.2 appropriations increase as a share of overall RDT&E, in part because overall RDT&E fell. In 1994, 6.2 appropriations declined as a share of DoD RDT&E to a 1992 level and as a share of Navy RDT&E to a 1991 level.

3. Advanced Technology Development (6.3a) Analysis

Figure 9 compares the appropriation for 6.3a to DoD and Navy RDT&E appropriations. The percentage change for 6.3a is shown for 1985 to 1994. Figures supporting this chart can be found in Table XI in the appendix.

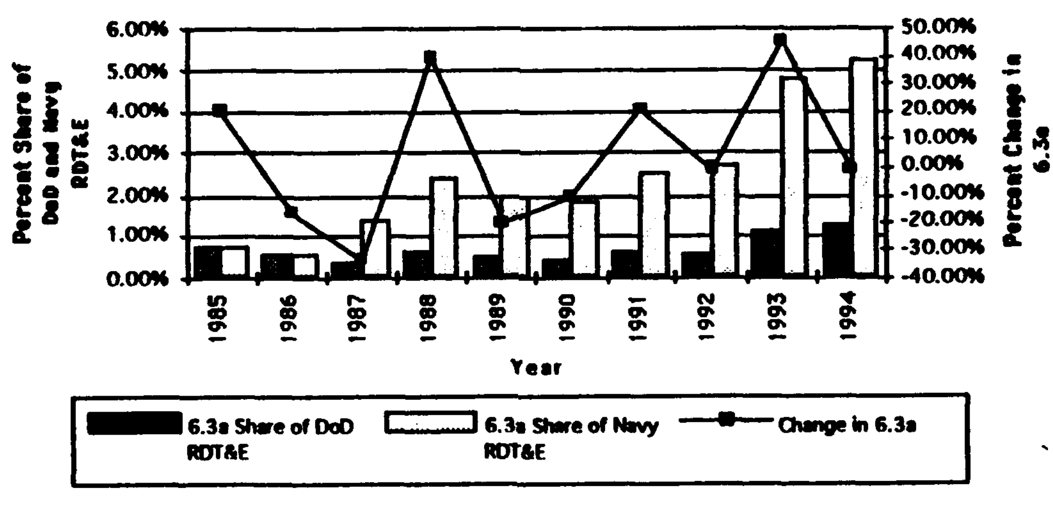

Figure 9. 6.3 Comparison to DoD and Navy RDT&E

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

By 1994, 6.3a appropriations increased 85 percent in real terms from 1984 levels. 6.3a appropriations fluctuated yearly with a maximum increase of 45 percent and a maximum decrease of 33 percent. No general or steady trends can be discerned. The 1993 increase in 6.3a involved funding for littoral warfare research.

The most significant change in 6.3a occurred during the 1992 to 1994 period. Appropriations for DoD and Navy RDT&E funding declined by over 15 percent and 7 percent respectively, while 6.3a appropriations increased by 8 percent. The increase came in spite of a HASC statement that S&T programs have become too costly. From 1984 to 1990, 6.3a appropriations varied widely. Overall 1990 appropriations decreased slightly when compared to 1984. DoD and Navy RDT&E funding reached a peak in 1986. They then declined to approximately 1984 levels by 1990.

E. APPROPRIATION SUMMATION

Appropriations were lowest for the 1984 through 1994 period in 1989 for 6.1 and 1990 for 6.2 and 6.3a. These S&T accounts grew until 1993. Starting in 1989 for 6.1 and 1990 for 6.2 and 6.3a, S&T appropriations increased as a share of DoD and Navy RDT&E, with the exception of 6.1 in 1992. In 1994, the first Clinton budget, appropriations for these Navy S&T accounts declined in real terms. However, with the exception of 6.2, S&T continued to increase as a share of DoD and Navy RDT&E.

Appropriations for DoD and Navy RDT&E peaked in 1986 and continuously declined through 1994. Budget requests and authorizations for DoD and Navy RDT&E peaked in 1988. S&T appropriations decreased at a faster rate than DoD RDT&E until 1989 for 6.1 and 6.2.

This data clearly shows a marked difference in S&T funding between the Reagan and Bush periods. During the Reagan period, a greater emphasis was placed on non-S&T RDT&E. This philosophical change in funding priorities for RDT&E funding is evidenced by the increase in Navy S&T relative to DoD and Navy RDT&E during the Bush period. In a time of declining DoD budgets, S&T held its own and did increasingly well.

Generally, appropriations constituted a growing share of Navy RDT&E, similar to the authorization trend, after 1988 for 6.1 and 6.2 and after 1989 for 6.3a. The exceptions to this trend were in 1994 for 6.1 and in 1990 and 1994 for 6.2. With the exception of decreases in 1992 for 6.2 and 6.3a as a share of DoD RDT&E, S&T funding constituted a larger share of DoD RDT&E after 1989. Again, this trend follows the pattern of authorizations over the same period. These trends point to a growing emphasis on S&T during the Bush years.

IV. THE NATURE OF CONGRESSIONAL INTERVENTION IN S&T

The previous chapter examined the funding trends within each part of the budget process. This chapter will examine the nature and scope of the changes made to the budget request by Congress. Basic Research, Exploratory Development, and Advanced Technology Development will be independently analyzed to determine the extent of the intervention. After that analysis, the concept of technology transfer will be explained, and then the Small Business Innovative Research (SBIR) program and the Navy Dual-Use Technology programs. These two programs represent a constraint upon the Navy's RDT&E budget. Finally, the Advanced Concepts and Technology Demonstrations (ACDT) will be discussed.

A. BUDGET PROCESS ANALYSIS

In this section, 6.1, 6.2, and 6.3a will be examined separately to determine the annual changes. Figures will be used to examine 6.1, 6.2, and 6.3a funding from 1984 to 1994. For this section, the president's budget request is the baseline. Comparing the authorization and appropriation figures to the budget request indicates the degree of Congressional intervention. Data presented in each chart are in thousands of 1994 dollars and complete data for each chart is in the appendix.

Recall that the budget request sets forth the president's financial plan and indicates his priorities for the federal government. The budget request formulation process reflects the continual exchange of information, proposals, evaluations, and policy decisions among the President, his staff, the Office of Management and Budget (OMB), and various government departments or agencies. Decisions regarding the upcoming budget are influenced by the results of previously enacted budgets, reactions to the last budget, and what is being considered by Congress. This budget formulation process also considers the resource needs of individual programs, and total outlays and receipts relative to current and projected economic conditions. [Ref. 26:pp. 5 and 4]

After the president's budget is submitted and reviewed by Congress, the legislature can then act to approve, modify, or disapprove the president's budget. However, virtually all congressional budget activities that take place throughout the rest of the process will use the President's budget as a starting point. Budget committees hold hearings to consider the whole budget, while Authorization and Appropriation committees hold hearings on specific parts of the budget within their legislative jurisdiction. The Congressional Budget Resolution is the Congress' budget and does not require executive approval. [Ref. 26:p. 6]

For a program to exist, an authorization must be passed. An authorization establishes the purposes and guidelines and, usually, sets ceilings on the amount that can be spent. The authorization does not provide actual funding. An appropriation must be passed so that a federal government agency can commit and obligate funds.

The appropriation for a program normally does not exceed the authorization ceiling. [Ref. 26:p. 6]

1. Basic Research (6.1) Analysis

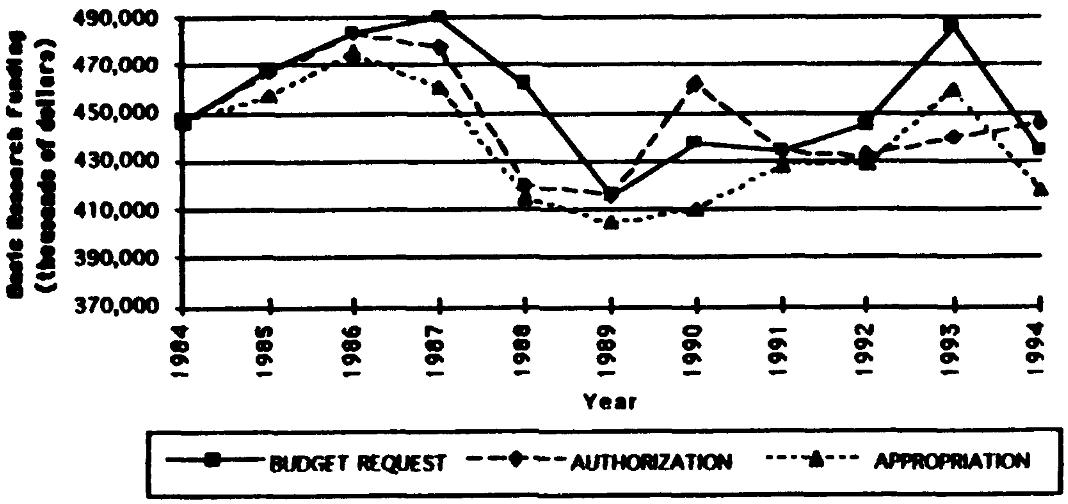

Figure 10. Basic Research Analysis

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

Congressional Budget Appropriations for the fiscal years 1984-1994.

Figure 10 compares the annual inflation-adjusted 6.1 budget requests, authorizations, and appropriations. Table XIII in the appendix presents a complete listing of all figures used in Figure 10.

From 1984 to 1986, all parties in the budget processes generally agreed on increased 6.1 funding, with each of the budget processes following its traditional role. In 1987 and 1988, budget requests were a weaker indication of funding authorizations and appropriations. Both authorizations and appropriations were significantly lower than the budget request during a period of declining funding. By 1989, the budget request did not differ from the authorization and was within 3 percent of the appropriation.

From 1990 through 1994, there was greater volatility in the budget processes. The budget process adhered less to the traditional roles. For example, the 1990 authorization was much larger than the budget request and appropriation and the 1993 authorization was less than the appropriation. During this period, the budget request was a poor indicator of the final appropriation.

2. Exploratory Development (6.2) Analysis

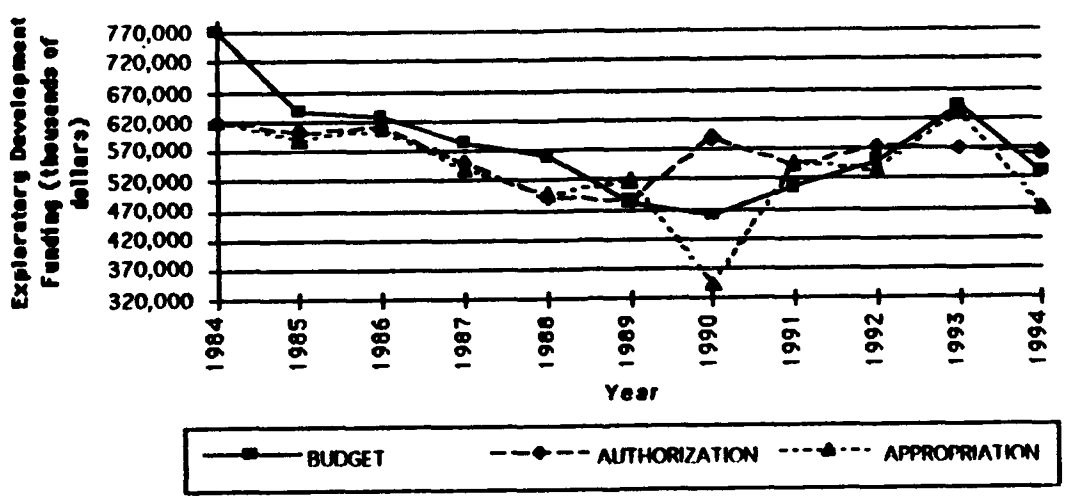

Figure 11. Exploratory Development Analysis

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

Congressional Budget Appropriations for the fiscal years 1984-1994.

Figure 11 compares annual inflation-adjusted 6.2 budget requests, authorizations, and appropriations. Table XIV in the appendix presents a complete listing of all amounts in Figure 11.

Two trends are apparent when comparing 6.2 budget submissions, authorizations, and appropriations between 1984 and 1988. First, budget requests, authorizations, and appropriations all steadily decreased through 1988, with authorizations being smaller than budget requests. Second, appropriations were within 2 percent of authorizations. From 1989 through 1994, there was greater degree of volatility among the budget processes. Authorizations exceeded the budget request in 1990 and 1994 and were less than the budget request and appropriation in 1993.

In 1989, the 6.2 budget request decreased 13 percent from the 1988 budget request. Again, that appears to mark the point when budget request levels dropped to or below anticipated authorization levels. In 1989 and 1991, 6.2 appropriations were larger than budget requests and authorizations. In both years, Congress expressed concern regarding technological surprises. [Ref. 30:p. 504 and Ref. 31:p. 482]

In 1990, efforts to consolidate programs or to drop programs lacking a firm direction gained steam, particularly in the appropriations committee. The 1990 authorization was 25 percent larger than the budget request. However, the appropriation was less than 60 percent of the authorization. Thus, the final appropriation was more than 25 percent less than the budget request.

3. Advanced Technology Development (6.3a) Analysis

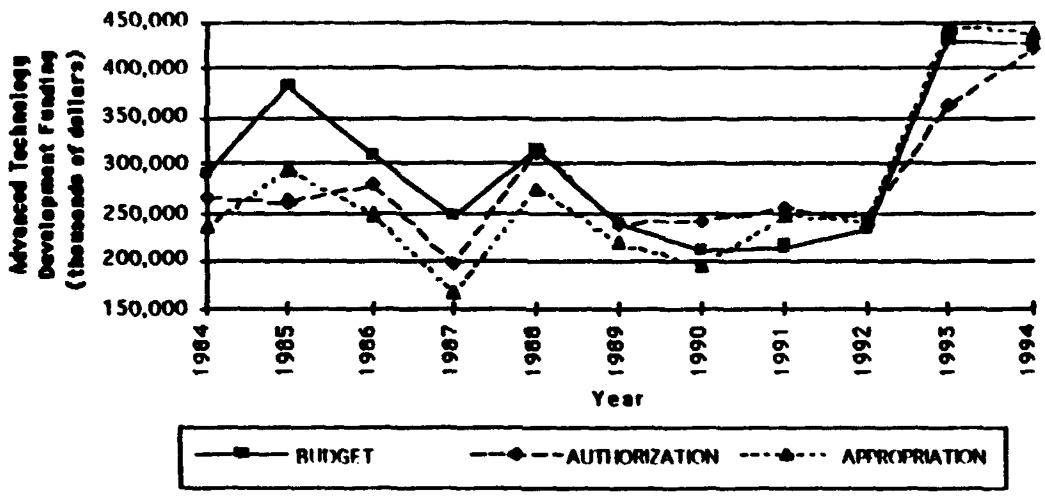

Figure 12. Advanced Technology Development Analysis

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

Congressional Budget Appropriations for the fiscal years 1984-1994.

Figure 12 compares annual inflation-adjusted 6.3a budget requests, authorizations, and appropriations. Table XV in the appendix presents a complete listing of all amounts in Figure 12.

As with 6.1 and 6.2, the 1984 to 1988 period had less change for 6.3a between each budget process than did the 1989 through 1994 period. Generally, from 1984 to 1988, authorizations were less than the budget request and appropriations were less than the appropriation. Authorizations reduced the budget request in each year through 1988. After 1988, the authorization committee provided higher funding levels than requested until 1993.

After 1988, the process demonstrated a greater volatility. During this period, budget requests were a poor indicator of the final appropriation. These budget requests were even worse indicators than for 6.1 and 6.2. After 1988, authorizations were lower than budget requests in only two years and appropriations were larger than the budget request and authorization in 1993 and 1994.

4. Budget Process Summation

The trends noted in Chapter III become more apparent in this budget process analysis. From 1985 through 1989 for 6.1 and 1990 for 6.2 and 6.3a, S&T budget requests, authorizations, and appropriations generally declined. Navy 6.2 and 6.3a funding trends were consistently downward. 6.1 funding increased through 1987 before declining to its low point in 1989.

All S&T budget categories increased funding from 1989 for 6.1 and 1990 for 6.2 and 6.3a through 1993. S&T experienced greater support during the Bush presidency. This trend reinforces the trend noted in Chapter III. The 1994 Clinton budget appears to have halted this trend. In 1994, the budget declined for 6.1 and 6.2 and held roughly constant for 6.3a.

No significant difference was noted between participants in the budget processes for 6.1. The changes to the budget requested by Congress were greater for 6.2 and even greater for 6.3a funding. This increased volatility for 6.3a was noted in Chapter III's analysis of the 6.3a account.

Generally, the period from 1985 to 1989 for Navy S&T showed a budget request that is larger than authorizations and appropriations. There is only one instance, 6.3a in 1985, where appropriations exceeded authorizations. The 1990 to 1994 period does show a greater degree of volatility between the budget request, authorization, and appropriation.

Specifically, 1990 stands out. For all S&T categories, the authorization exceeded the request which exceeded the appropriation. The 1990 Bush S&T budget focus was to invest in new technology and guard against technological surprise. The Navy Basic Research budget increased 5 percent while the budget for Exploratory Development and Advanced Technology Development declined by 5 percent and 11 percent respectively. [Ref. 34:pp. I631-I632]

The SASC, in its report on the president's budget, noted that DoD S&T lacked clear priorities, adequate funding, and conformity of goals. The DTIB had the highest priority and there was a perception that the defense and civilian industrial bases were becoming less distinguishable and that the president's budget did not adequately support the industrial base. [Ref. 35:pp. 17-18] The appropriators, as stated in the Conference Report on the Defense Budget, saw a DoD RDT&E budget with excessive waste and duplication. They even stated that some programs had limited military applicability. [Ref 36:p. 102]

In the next section, two types of technology transfers will be analyzed. SBIR and Dual-Use Technology Development are technology transfers that are funded by S&T. The congressional mandates of these programs constitute a growing constraint on Navy S&T.

B. TECHNOLOGY TRANSFER

The concept of technology transfer from the military sector to the commercial sector has been discussed at great length. There is a belief that defense research funding can be spent more productively. "More productively" means that these dollars can be used to meet defense requirements, but also to have some applications for the commercial sector.

There are three types or definitions of technology transfer involving DoD: spin-off, spin-on, and dual-use technology. Traditionally, technology transfer was viewed as a one-way process, moving technology developed in federal programs to commercial applications. This is known as a "spin-off." [Ref. 27:p. 29] Technology development in this instance is not sensitive to market forces in the commercial sector. In the past, DoD assumed that defense technologies would simply spin-off into commercial applications, more or less on their own.

"Spin-on" technology holds that the best commercial technology can be adopted for military uses. Frequently this technology must be adapted. Spin-on conflicts with the traditional DoD practice of developing technology in-house. Militarily adapted commercial technology requires the military to alter existing technology for its needs. This may reduce performance as a tradeoff for enhancing economic competitiveness. [Ref. 27:p. 29] The current military procurement system prefers developing new systems rather than purchasing existing weapon systems. Modifying this system should facilitate adapting commercially developed products.

Dual-use technology development is another form of technology transfer. Dual-use technology development takes advantage of the collaborative pull of the defense and commercial market places to develop needed technology. Dual-use technologies have military and civilian applications. Wherever possible, DoD is emphasizing technology that is dual-use rather than military-unique. This represents a clear break from the past, when making the fruits of military research available to the public was not a high priority. Designing technology with two purposes, military and civilian, places DoD in an awkward position where it must weigh a technology's military potential against the benefits its procurement may have on the nation's economy. [Ref 28:p. 91]

Some experts believe that the best modes for technology transfer are spin-on and dual-use. Two programs representing each of these two types of technology transfers are examined below. Each program, in essence, places a constraint upon the military's research procurement options.

1. Small Business Innovative Research (SBIR)

The Small Business Innovative Development Act of 1982 sought to encourage technology innovation primarily by requiring federal agencies to award portions of their research funds to small businesses though special SBIR programs. The act was a result of congressional interest in scientific innovation and the nation's economic growth. The premise of the act is that small businesses have become a significant source of technological innovation. The act attempted to increase small business participation in federal research and development. [Ref 29:p. 1] SBIR is a spin-on type of technology transfer.

All major federal research agencies, DoD included, are required to set up special SBIR programs. The law mandates that these federal agencies devote a proportion (at least 1.25 percent) of external research dollars to this program. [Ref 30: pp. 64-65] The Small Business Administration (SBA) monitors compliance with the act. The SBA has defined a small business as a for-profit firm with fewer than 500 employees. [Ref 29:p.1]

Proponents of the Small Business Innovative Development Act of 1982 argued that federal R&D procurement systems favored large firms and universities. SBIR funding guarantees that the small business sector receives an appropriate share of federal R&D funding. Opponents of this act questioned whether other means of increasing small business research participation might be more appropriate. Also, this mandatory funding constraint would put pressure on already tight federal agency

R&D budgets, thereby causing the services to procure less desirable research. [Ref 29:pp. 1-4]

SBIR contracts are considered useful for a number of reasons. The SBIR program supports innovative technologies being developed by small business. This act clearly offers opportunities to "spin-on" commercial technology from small business innovations. This is an increasingly popular method to focus resources on pre-competitive technology. [Ref. 27:p. 34] These programs offer potential cost minimization for technology development and speed technology transfer that enhance U.S. economic competitiveness.

The Navy SBIR program element, as shown in the DoD RDT&E Programs (R-1) for fiscal year 1994, included an entry for SBIR in fiscal years 1993 and 1994. Under Secretary Aspin, DoD has more actively supported these technology transfer programs. The Navy SBIR program element, as shown in the 1994 R-1, receives its funding from 6.1 or Basic Research. In 1993 SBIR funding was $81,443,000. That amounted to 7.5 percent of Navy 6.1 funding and 0.912 percent of Navy RDT&E funding. For 1994, SBIR was allocated $86,113,000. That is a 5.7 percent increase over 1993 funding. SBIR funding consumed 8.9 percent of Navy 6.1 and 0.934 percent of Navy RDT&E. The SBIR program funding has accounted for a greater share of available Naval research funding. [Ref. 3:p. N-1]

2. Navy Dual-Use Technology Programs

The Navy Dual-Use Technology program is an extension of the 1992 Defense Conversion, Reinvestment, and Transition Act. This act is implemented by means of the Technology Reinvestment Project (TRP) to be administered by the Advanced Research Projects Agency (ARPA). This act reflected the Congress' desire to pull down barriers to effective technologies transferred between the public and private sectors. It is intended that TRP will "demonstratably" enhance U.S. economic competitiveness. [Ref. 27:pp. 16-17]

The purpose of this new program is to develop dual-use technologies that will enhance the economic viability and competitiveness of U.S. industry in technological areas of particular relevance to the Navy. This is a form of dual-use technology transfer that will be funded for the first time in the 1995 budget. According to the FY 1995 Navy Descriptive Summary for RDT&E, the proposed fiscal year 1995 funding for this program is $50,000,000 for 6.1, 6.2, and 6.3a. This program emphasizes technology creation, fostering technology transfer and enhancing the U.S. Defense Technology Industrial Base. This is the primary Navy program for developing new technology in areas of critical Navy interest.

3. Summation

Currently, SBIR is over 50 percent larger than Dual-Use Technology programs. A greater share of funding was allocated to SBIR in 1994 than in 1993. This occurred despite a S&T funding decline in 1994. A greater share of S&T funding went to SBIR as 6.1 declined. The Navy has lost some degree of control over nearly 9 percent of its Basic Research budget.

The Navy Dual-Use Technology program is new and only the President's FY 1995 budget figures are available. This program, like SBIR, is a constraint on

S&T research procurement options. It mandates that the Navy focus less on procurement of military specific items and more on economic vitality of a certain segment of the civilian sector.

C. ADVANCED CONCEPTS AND TECHNOLOGY DEMONSTRATIONS (ACDT)

ACDT is considered the first change in weapon system procurement under President Clinton. Since this is the first change to DoD RDT&E by President Clinton, it could represent one future direction of DoD RDT&E. The goal of ACDT is to fund prototypes or demonstrations for 20 to 40 technology projects judged critical for developing weapons. Prototypes are funded through the 6.3a and 6.3b accounts. ACDT will not replace the current DoD procurement system. This effort will affect Advanced Technology Development and Advanced Development. This will be an additional phase of the acquisition process. This is an integrating effort involving very substantial cooperation and participation of those who use and who develop tech ology. By refining operational requirements and concept designs, the new systems can be developed with minimal cost or delay. [Ref. 33:p.3]

DoD currently has 150 demonstrations competing for funding. To change this situation, the ACDT program will reduce the number of demonstrations and use the saving to pay for the ACDT program. This program is also designed to provide work for defense firms facing reduced funding due to decreased weapon system procurement.

V. THE SIGNIFICANCE OF ADVANCED PROTOTYPES

A. ADVANCED TECHNOLOGY DEVELOPMENT

Advanced Technology Development (6.3a) focuses on demonstrating how components of a system work together; it is the most mature S&T stage. This chapter will examine the implication of Advanced Technology Demonstration (ATDs) and Enhanced Technology Demonstrations (ETDs) on the 6.3a account. ATDs and ETDs represent an effort to take advantage of high technology demonstrations and refine the prototyping process. These advanced or enhanced technology demonstrations have the potential to help maintain the industrial base. Budget figures used for all analyses are inflation adjusted and utilize 1994 as the base year for comparison. A complete listing of all figures for all three charts in this chapter can be found in the appendix.

B. TECHNOLOGY DEVELOPMENT IN ACQUISITION

In April of 1992, while still the Chairman of the House Armed Service Committee, Mr. Aspin outlined a technology development strategy that offered the flexibility that the U.S. would require to deal with threats in the post-Cold War, post-Soviet world. The strategy involved four approaches for maintaining critical areas of the DTIB. The four approaches are selective upgrading, selective low-rate procurements, silver bullet procurements, and rollover plus.

The first two approaches aim at sustaining a minimum production capability in defense-unique industries. Selective upgrading would improve weaponry without the expense of new systems. Selective low-rate procurements would purchase current-generation systems and components as needed. Silver bullet procurements involve systems that leverage the U.S. high technology advantage. The F-117's success during Operation Desert Storm illustrates the value of silver bullets. Rollover plus is a continuous process of systems protoyping and development, without a commitment up front to production. Basically, it involves "rolling" over technology from one development cycle to another until the technology is required in the field or some narrow production criteria are met. [Ref. 23:pp. 1-4] Rollover Plus uses prototypes to demonstrate a potentially important or high pay-off technology. Mr. Aspin clearly understood the importance of prototyping for military and civilian sectors.

In 1992, Mr. William Perry, Co-Director of the Stanford Center for International Security and Arms Control, testified before the HASC that technology demonstration to test new ideas is critical to determining which technology should enter production. After identifying a new high-leverage technology that will provide a definitive military advantage, the U.S. should build a demonstration system and test the concept. [Ref. 27:p. 358]

The 6.3a account is designed to focus on identifying new ideas with high defense payoff potential. 6.3a can be thought of as the "show me" phase of the DoD

S&T program. Technology demonstrations are not something new. Stealth technology and the Joint Surveillance Target Attack System (JSTARS) are two examples of technology demonstrations yielding a weapon system.

Even as DoD's budget for new systems is cut back, DoD's need to maintain technological superiority is as important as ever. Technology is a force multiplier and certainly helps minimize U.S. casualties. Operation Desert Storm showed how technology can save lives. Even though the defense budget has decreased, funding for ATDs and ETDs has increased. Both ATD and ETD program elements are funded through the 6.3a account. The ATD program includes the Generic Logistics R&D Technology Transition and the Marine Corps ATD. The ETD program includes the Undersea Warfare ATD and Global Surveillance/Air Defense/Precision Strike Technology Demonstrations.

ATDs and ETDs are increasing in scope, depth and importance. In funding current and future ATDs and ETDs, DoD must concentrate on proving the maturity and utility of a broad range of technology. ATDs and ETDs are designed to prove the feasibility and producibility of a technological concept and to reduce risk in the system acquisition process. The focus is on technology and not on a total operational system. Technology demonstrations reduce risk by helping to determine which technology can pay off. They also provide technology options that hedge against potentially new and unexpected large-scale threats that could emerge in the future.

C. ATD ANALYSIS

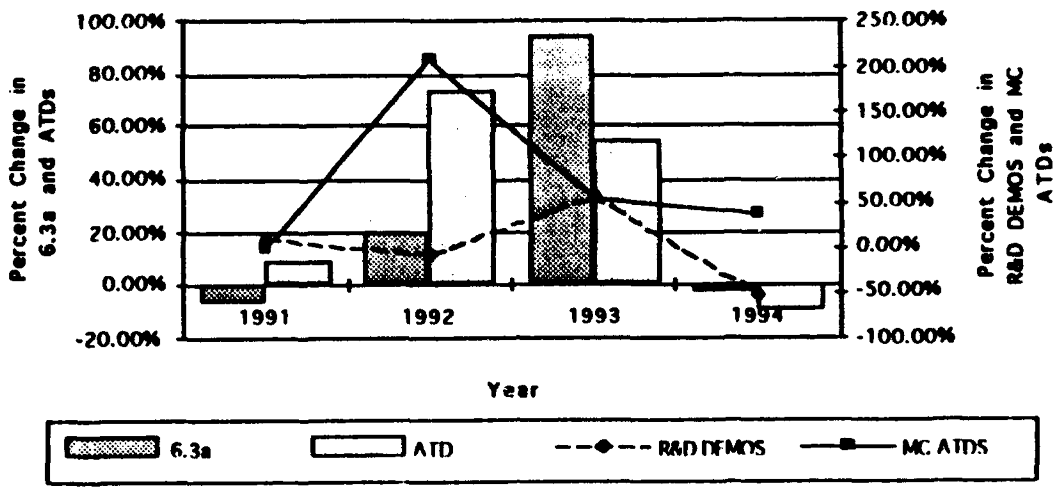

Figure 13. ATD Funding Analysis

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

Figure 13 shows the annual change between 1991 and 1994 in overall 6.3a and ATD funding, and in the two ATD components, Generic Logistics R&D Technology Demonstrations (R&D DEMOS) and Marine Corps ATD (MC ATD). Figure 13 shows that the R&D DEMOS series grew at a slower rate than ATD in all years but 1993. MC ATD funding has the opposite trend. The MC ATD budget has increased since its inception in 1992, rising 54 percent in 1993 and 38 percent in 1994. As such, it has grown at least as fast as ATD funding from 1991 to 1994. Funding for ATD and R&D DEMOS declined in 1994, while MC ATD continued to increase. Figures used in Figure 13 can be found in the appendix in Tables XVI and XVII.

ATD funding as a share of 6.3a funding increased from 9 percent to 14 percent in 1992. Then it declined slightly to 13 percent by 1994. Even though Marine Corps

ATD funding was increasing in 1993 and 1994, it was not enough to offset the decline in Generic Logistics R&D DEMOS. The R&D Technology Demonstration program element declined by nearly 55 percent in 1994.

D. ETD ANALYSIS

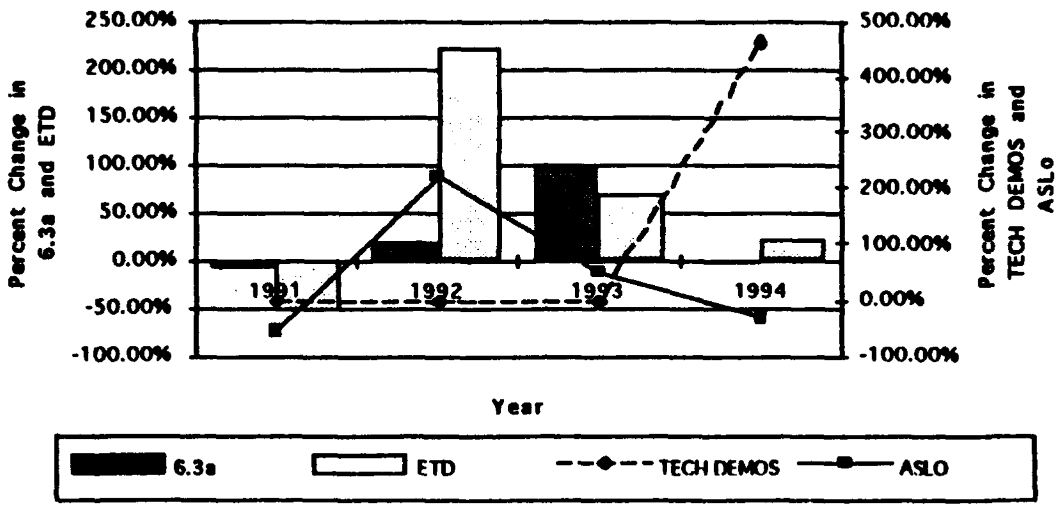

Figure 14. ETD Funding Analysis

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

Figure 14 shows the annual change between 1991 and 1994 in overall 6.3a and ETD funding, and in the two ETD components, Advanced Anti-Submarine Warfare (ASW) Technology Demonstrations (ASLO) and Global Surveillance/Air Defense/Precision Strike Technology Demonstrations (TECH DEMO). Funding for TECH DEMOs began in 1993. Advanced ASW Technology Demonstrations were funded in all years of this analysis. ASLO increased by nearly 205 percent in 1992 after a decrease of over 57 percent in 1991. Funding for ASW Technology Demonstrators increased further in 1993 but declined by 36 percent in 1994. The Global Surveillance/Air Defense/Precision Strike Technology Demonstrations program element increased each year it was funded, with 1994 funding increasing by over 400 percent. Figures used in Figure 14 can be found in the appendix in Tables XVIII and XIX.

ETD funding as a share of 6.3a increased in each year but 1993. ETD funding as a share of 6.3a would have decline in 1994 if it were not for the dramatic increase in funding for Global Surveillance/Air Defense/Precision Strike Technology Demonstrations.

E. ATD AND ETD ANALYSIS

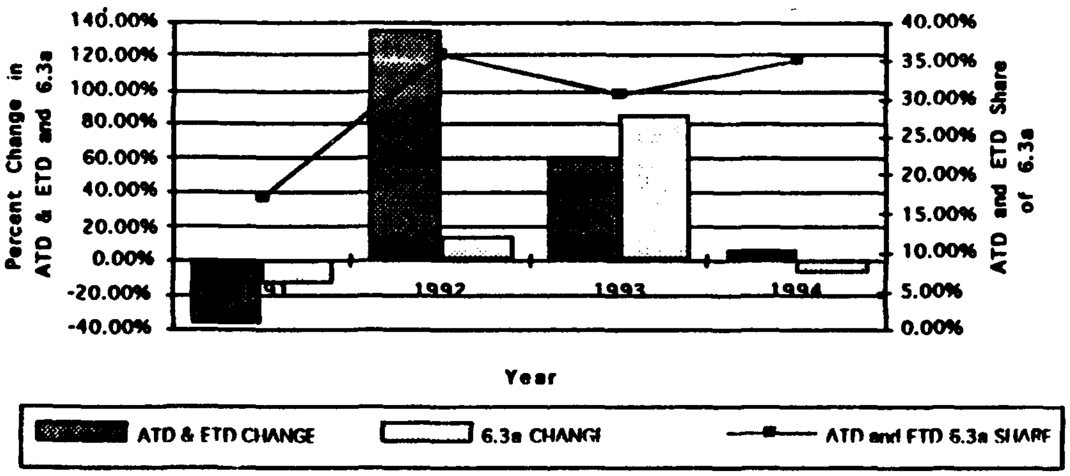

Figure 15. ATD & ETD Funding Analysis

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

The ATD & ETD change series in Figure 15 shows that ATD and ETD Technology Demonstrations funding increased dramatically in 1992 after a decline in 1991. Funding increases were successively smaller in 1993 and 1994. The 6.3a change series in Figure 15 shows 6.3a funding increasing in 1992 and 1993. In 1991 and 1994, 6.3a funding declined.

By 1992, ATD and ETD funding as a share of 6.3a was over 35 percent, shown by the share of 6.3a series in Figure 15. In 1993, ATD and ETD funding grew by 62 percent while 6.3a funding grew by 95 percent. Despite the relatively large increase in overall 6.3a funding, the ATD and ETD funding accounted for more than 30 percent of 6.3a in 1993 and 1994.

F. SUMMATION

ATD funding increased until FY 1993. The 1994 budget brought a decrease in funding for ATD. ETD continued to see funding increases for the entire period observed. The increase in funding for ETD in 1994 offset the decrease in ATD and allowed their combined funding to increase slightly. Both ATD and ETD are found within the 6.3a account. Despite the decrease in 6.3a funding for 1994, advanced prototyping in general received increases in funding.

VI. CONCLUSION

A. CHANGES TO THE NAVY S&T BUDGET

1. Budget Requests

From 1984 to 1988, DoD RDT&E and, from 1984 to 1986, Navy RDT&E, amounts requested increased. The 1989 through 1994 period is marked by declining support for DoD and Navy RDT&E. While DoD and Navy RDT&E were generally increasing, budget requests for 6.1 were lower in 1989 than in 1984 and budget requests for 6.2 and 6.3a were lower in 1990 than in 1984.

Generally, budget requests for DoD and Navy RDT&E continued to decline from 1989 until 1994. Budget requests for Navy S&T increased. A clear shift in support is noted towards less mature types of technology research, while more technologically mature types of research lost support.

2. Authorizations

Following a slightly different trend than budget requests, DoD RDT&E authorizations generally increased through 1988. Until 1989, Navy S&T authorizations generally declined, with the exception of an increase for 6.1 in 1986 and in 6.3a in 1988. DoD and Navy RDT&E authorizations gradually declined from 1989 through 1994. Navy S&T authorizations began increasing in 1990 and generally continued through 1994. Congressional authorizations didn't reduce Navy S&T as occurred with the 1994 budget request.

3. Appropriations

DoD RDT&E appropriations increased until 1986 and Navy RDT&E appropriations increased until 1985. This increase did not last as long as it did for the budget request or authorization. The appropriations sent a clearer signal of tighter RDT&E budgets to come. DoD and Navy RDT&E appropriations began a period of gradual decreased funding.

Appropriations for 6.1 increased until 1986 and appropriations for 6.3a increased only until 1985. Generally, in 1984 6.2 appropriations began a decline that would last until 1990. Appropriations were at their low point for 6.1 in 1989 and for 6.3a in 1990. Thereafter, Navy S&T appropriations increased until 1993. The 1994 appropriation was similar to the budget request in that all types of research funding declined.

B. TECHNOLOGY TRANSFERS

The growing importance of DoD research in support of technological development in the commercial sector is increasingly visible. Technological transfer programs such as the Small Business Innovative Research (SBIR) program and the Navy Dual-Use Technology program are more prominent in recent Navy budgets. SBIR funding increased in 1994 while funding for S&T declined. These programs represent a constraint on the Navy's ability to determine and procure the research that best meets its needs.

C. ADVANCED PROTOTYPES

As funding for production of new weapon systems declines, the importance of advanced prototypes or demonstrations of technology grow larger. The proposed Advanced Concepts and Technology Demonstrations (ACDT) along with Advanced Technology Demonstrations (ATDs) and Enhanced Technology Demonstrations (ETDs) are forms of technology demonstrations that are funded in the 6.3a account.

Funding for ATDs and ETDs increased every year until 1994. Despite a 1994 funding increase for ATDs and ETDs combined, ETD funding increases had a more pronounced effect. Both ATDs and ETDs are funded through 6.3a. Both types of demonstrations continue to grow in importance. Despite a decline in funding for 6.3a in 1994, these demonstrations managed a modest increase.

D. SUGGESTIONS FOR FURTHER STUDY

Two areas are suggested for further study: industrial policy and management control of R&D.

1. Industrial Policy

Changes in the international security environment require the United States to make some far reaching decisions about the size and character of the U.S.

Armed Forces and the Defense Technology and Industrial Base (DTIB). In supporting those forces, the DTIB has two basic functions:

1. Developing, producing, and supporting military systems in peacetime; and
2. Responding to increased military requirements in crisis or war. [Ref. 2:p. 3]

The key question facing the Nation's leaders is how to retain the technology and industrial capabilities essential for the nation's defense and interests with reduced defense budgets.

The DTIB is the combination of people, institutions, technological expertise, and facilities used to design, develop, manufacture, and maintain the weapons and supporting defense equipment needed to meet U.S. national security objectives. [Ref. 8:pp. 2-3]

There is little debate among government policy makers that to remain globally engaged U.S. must retain both sufficient military forces and the means to arm and support those forces. Yet, it is certain that the defense budget will not grow larger. With fewer funds available for military procurement, a shakeout will occur in the defense industrial sector. [Ref. 2:pp. 3-4] The main justification for a federal DTIB policy is to ensure that critical defense industrial sectors are capable of producing weapon systems in a time of emergency.

The DTIB is not independent of the larger civilian industrial base. The American industrial base is becoming increasingly global, with many multinational firms. Except for crisis situations, developing and implementing a U.S. industrial strategy is complicated by the numerous groups that must cooperate. The Reagan and Bush Administrations opposed an industrial policy. Both administrations preferred to allow market forces to decide the fate of the defense industry. On the other hand, some in Congress and in the current administration seem to favor an industrial policy. [Ref. 10:pp. 9-11]

At the heart of this debate is the preservation of the technology or industrial base. National security is firmly linked to the country's ability to produce military hardware as needed. Reconstitution is the ability to expand the military force to respond to a perceived threat. Reconstitution requires, among other things, a DTIB that can produce weapons in a timely manner to support an expanding force and the ability to mobilize reserve manpower. [Ref. 14:pp. 2-4]

An area of suggested study is examining of the impact of DoD or Navy S&T funding on the industrial base. This study can assess the impact of DoD or Navy S&T spending. Can present funding levels support the required industrial base and have past funding levels been adequate to support the industrial base?

2. Management Control of R&D

Basic research has two characteristics. First, it is unplanned. Management can at most specify general areas in which to conduct research or explore. Second, there is a long time lag between basic research and new product introduction. Exploratory research is relatively inexpensive and unstructured. Effort quantification is difficult. [Ref. 22:p. 141] As one moves along the R&D continuum to full scale production, controls become more formal and expenditures increase.

Engineering, testing, and development are direct costs. Cost estimation is simplified and management can implement process control more easily. [Ref. 22:pp. 141-142]

The primary research group receiving funding in an R&D phase reflects the level of financial and managerial control. In basic research, where the stakes are still low, most funding is allocated to universities. This reflects the unstructured, relatively inexpensive nature of the work being done. In applied R&D, the funding is split more evenly among universities, industry and in-house facilities. Industry overwhelmingly controls development funding. This phase is characterized by strict financial control tied to profitability.

In later research and development phases, industrial involvement is more pronounced, due to the ease of linking R&D costs to certain products. It is much more difficult to link a portion of a product's development cost to basic research. This helps explains why private firms are not significantly involved in basic research. Further study might inquire as to the possible measures of effectiveness of DoD and Navy RDT&E expenditures. This study could access the impact of the different categories of R&D investment.

APPENDIX

TABLE I

BUDGET SUBMISSIONS (CURRENT DOLLARS)

Year	DoD RDT&E	Navy RDT&E	6.1	6.2	6.3a
1994	38,620,327	9,215,604	433,907	530,119	425,288
1993	38,812,700	8,517,800	473,569	622,534	418,533
1992	40,073,100	8,194,233	421,635	520,538	221,110
1991	38,092,800	9,017,100	401,158	466,335	199,605
1990	39,545,300	9,830,300	390,352	411,312	188,021
1989	38,157,100	9,216,200	356,752	415,887	204,024
1988	43,718,937	10,490,412	380,801	460,145	258,472
1987	41,929,900	10,586,800	388,831	462,217	196,272
1986	39,280,100	11,264,300	371,703	481,466	239,449
1985	33,985,037	9,826,076	350,346	477,826	286,399
1984	29,625,266	8,182,419	324,674	559,662	210,975

Sources: Presidential Budget Submissions for the fiscal years 1984 -1994.

TABLE II

6.1 COMPARISON TO DOD AND NAVY RDT&E

Year	6.1	Increase	DoD RDT&E	6.1 as a % of DoD RDT&E	Navy RDT&E	6.1 as a % of Navy RDT&E
1994	433,907	-10.76%	38,620,327	1.12%	9,215,604	4.71%
1993	486,210	8.61%	39,848,768	1.22%	8,745,175	5.56%
1992	444,341	2.25%	42,231,110	1.05%	8,635,507	5.15%
1991	434,342	- 0.73%	41,243,828	1.05%	9,762,993	4.45%
1990	437,516	5.00%	44,323,358	0.99%	11,018,045	3.97%
1989	415,650	-10.08%	44,456,600	0.93%	10,737,737	3.87%
1988	462,249	- 5.62%	53,069,843	0.87%	12,734,173	3.63%
1987	489,773	1.34%	52,815,090	0.93%	13,335,181	3.67%
1986	483,233	3.22%	51,066,173	0.95%	14,644,176	3.30%
1985	467,689	4.48%	45,367,824	1.03%	13,117,175	3.57%
1984	446,717		40,761,236	1.10%	11,258,144	3.97%

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

TABLE III

6.2 COMPARISON TO DOD AND NAVY RDT&E

YEAR	6.2	Increase	DoD RDT&E	6.2 as a % of DoD RDT&E	Navy RDT&E	6.2 as a % of Navy RDT&E
1994	530,119	20.57%	38,620,327	1.37%	9,215,604	5.75%
1993	639,152	14.17%	39,848,768	1.60%	8,745,175	7.31%
1992	548,570	7.96%	42,231,110	1.30%	8,635,507	6.35%
1991	504,910	8.69%	41,243,828	1.22%	9,762,993	5.17%
1990	461,009	- 4.86%	44,323,358	1.04%	11,018,045	4.18%
1989	484,547	-13.25%	44,456,600	1.09%	10,737,737	4.51%
1988	558,564	- 4.06%	53,069,843	1.05%	12,734,173	4.39%
1987	582,211	- 6.98%	52,815,090	1.10%	13,335,181	4.37%
1986	625,931	- 1.87%	51,066,173	1.23%	14,644,176	4.27%
1985	637,867	-17.16%	45,367,824	1.41%	13,117,175	4.86%
1984	770,036		40,761,236	1.89%	11,258,144	6.84%

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

TABLE IV

6.3A COMPARISON TO DOD AND NAVY RDT&E LEVELS

YEAR	6.3a	Increase	DoD RDT&E	6.3a as a % of DoD RDT&E	Navy RDT&E	6.3a as a % of Navy RDT&E
1994	425,288	- 1.03%	38,620,327	1.10%	9,215,604	4.61%
1993	429,705	45.77%	39,848,768	1.08%	8,745,175	4.91%
1992	233,017	7.25%	42,231,110	0.55%	8,635,507	2.70%
1991	216,116	2.49%	41,243,828	0.52%	9,762,993	2.21%
1990	210,739	-11.35%	44,323,358	0.48%	11,018,045	1.91%
1989	237,707	-24.24%	44,456,600	0.53%	10,737,737	2.21%
1988	313,756	21.20%	53,069,843	0.59%	12,734,173	2.46%
1987	247,225	-20.58%	52,815,090	0.47%	13,335,181	1.85%
1986	311,296	-18.58%	51,066,173	0.61%	14,644,176	2.13%
1985	382,324	24.08%	45,367,824	0.84%	13,117,175	2.91%
1984	290,279		40,761,236	0.71%	11,258,144	2.58%

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

TABLE V

BUDGET AUTHORIZATION (CURRENT DOLLARS)

YEAR	DoD RDT&E	Navy RDT&E	6.1	6.2	6.3a
1994	37,885,398	8,736,970	445,407	562,019	419,527
1993	39,613,600	8,984,717	428,569	555,567	353,259
1992	40,056,600	8,633,875	410,267	545,302	232,473
1991	36,095,900	9,417,934	401,158	501,335	235,605
1990	38,227,000	10,140,400	411,917	526,121	216,705
1989	37,970,200	9,383,200	356,752	416,887	205,524
1988	40,511,225	9,947,151	346,229	402,552	258,406
1987	36,215,600	9,294,106	379,227	436,069	156,860
1986	35,488,754	10,106,401	371,703	469,132	214,813
1985	32,080,263	9,408,596	349,721	452,673	195,949
1984	27,302,908	7,619,409	324,674	450,767	192,531

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

TABLE VI

6.1 COMPARISON TO DOD AND NAVY RDT&E

YEAR	6.1	Increase	DoD RDT&E	6.1 as a % of DoD RDT&E	Navy RDT&E	6.1 as a % of Navy RDT&E
1994	445,407	1.23%	37,885,398	1.18%	8,736,970	5.10%
1993	440,009	1.74%	40,671,047	1.08%	9,224,555	4.77%
1992	432,361	- 0.46%	42,213,721	1.02%	9,098,825	4.75%
1991	434,342	- 5.92%	39,081,745	1.11%	10,196,984	4.26%
1990	461,687	9.97%	42,845,774	1.08%	11,365,613	4.06%
1989	415,650	- 1.10%	44,238,844	0.94%	10,932,308	3.80%
1988	420,283	-12.02%	49,176,044	0.85%	12,074,716	3.48%
1987	477,676	- 1.15%	45,617,332	1.05%	11,706,898	4.08%
1986	483,233	3.39%	46,137,226	1.05%	13,138,847	3.68%
1985	466,855	4.31%	42,825,074	1.09%	12,559,867	3.72%
1984	446,717		37,565,916	1.19%	10,483,502	4.26%

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

TABLE VII

6.2 COMPARISON TO DOD AND NAVY RDT&E

YEAR	6.2	Increase	DoD RDT&E	6.2 as a % of DoD RDT&E	Navy RDT&E	6.2 as a % of Navy RDT&E
1994	562,019	- 1.47%	37,885,398	1.48%	8,736,970	6.43%
1993	570,397	- 0.75%	40,671,047	1.40%	9,224,555	6.18%
1992	574,668	5.54%	42,213,721	1.36%	9,098,825	6.32%
1991	542,805	- 7.95%	39,081,745	1.39%	10,196,984	5.32%
1990	589,690	17.63%	42,845,774	1.38%	11,365,613	5.19%
1989	485,712	- 0.61%	44,238,844	1.10%	10,932,308	4.44%
1988	488,653	-11.04%	49,176,044	0.99%	12,074,716	4.05%
1987	549,274	- 9.94%	45,617,332	1.20%	11,706,898	4.69%
1986	609,896	0.92%	46,137,226	1.32%	13,138,847	4.64%
1985	604,289	- 2.57%	42,825,074	1.41%	12,559,867	4.81%
1984	620,208		37,565,916	1.65%	10,483,502	5.92%

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

TABLE VIII

6.3A COMPARISON TO DOD AND NAVY RDT&E LEVELS

YEAR	6.3a	Increase	DoD RDT&E	6.3a as a % of DoD RDT&E	Navy RDT&E	6.3a as a % of Navy RDT&E
1994	419,527	15.67%	37,885,398	1.11%	8,736,970	4.80%
1993	362,689	32.45%	40,671,047	0.89%	9,224,555	3.93%
1992	244,992	- 4.12%	42,213,721	0.58%	9,098,825	2.69%
1991	255,094	5.03%	39,081,745	0.65%	10,196,984	2.50%
1990	242,888	1.41%	42,845,774	0.57%	11,365,613	2.14%
1989	239,455	-31.00%	44,238,844	0.54%	10,932,308	2.19%
1988	313,676	58.76%	49,176,044	0.64%	12,074,716	2.60%
1987	197,582	-29.25%	45,617,332	0.43%	11,706,898	1.69%
1986	279,268	6.33%	46,137,226	0.61%	13,138,847	2.13%
1985	261,579	- 1.25%	42,825,074	0.61%	12,55[illegible],867	2.08%
1984	264,902		27,565,916	0.71%	10,483,502	2.53%

Sources: Congressional Budget Authorizations for the fiscal years 1984-1994.

TABLE IX

BUDGET APPROPRIATIONS (CURRENT DOLLARS)

YEAR	DoD RDT&E	Navy RDT&E	6.1	6.2	6.3a
1994	34,946,384	8,365,786	417,407	468,606	437,354
1993	37,962,158	8,930,381	447,257	612,910	432,059
1992	39,176,446	8,557,635	406,767	508,286	230,729
1991	35,722,072	9,037,684	395,703	503,469	227,055
1990	36,956,171	9,773,174	366,077	306,528	174,303
1989	37,442,733	9,382,312	346,752	445,849	188,349
1988	36,814,979	9,535,619	342,016	407,951	226,798
1987	35,804,214	9,326,416	365,668	429,728	132,072
1986	35,337,505	10,065,239	365,735	466,164	191,085
1985	31,187,071	9,172,622	342,698	443,190	221,477
1984	26,690,269	7,559,818	324,674	450,767	171,528

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

TABLE X

6.1 COMPARISON TO DOD AND NAVY RDT&E

YEAR	6.1	Increase	DoD RDT&E	6.1 as a % of DoD RDT&E	Navy RDT&E	6.1 as a % of Navy RDT&E
1994	417,407	-9.10%	34,946,384	1.19%	8,365,786	4.99%
1993	459,196	6.65%	38,975,522	1.18%	9,168,769	5.01%
1992	428,672	0.06%	41,286,169	1.04%	9,018,479	4.75%
1991	428,435	4.23%	38,676,994	1.11%	9,785,279	4.38%
1990	410,308	1.54%	41,421,398	0.99%	10,954,017	3.75%
1989	403,999	-2.69%	43,624,296	0.93%	10,931,273	3.70%
1988	415,169	-9.86%	44,689,219	0.93%	11,575,163	3.59%
1987	460,597	-3.13%	45,099,149	1.02%	11,747,595	3.92%
1986	475,475	3.78%	45,940,594	1.03%	13,085,334	3.63%
1985	457,480	2.35%	41,632,721	1.10%	12,244,856	3.74%
1984	446,717		36,722,990	1.22%	10,401,511	4.29%

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

TABLE XI

6.2 COMPARISON TO DOD AND NAVY RDT&E

YEAR	6.2	Increase	DoD RDT&E	6.2 as a % of DoD RDT&E	Navy RDT&E	6.2 as a % of Navy RDT&E
1994	468,606	-25.53%	34,946,384	1.34%	8,365,786	5.60%
1993	629,271	14.88%	38,975,522	1.61%	9,168,769	6.86%
1992	535,658	- 1.73%	41,286,169	1.30%	9,018,479	5.94%
1991	545,116	36.97%	38,676,994	1.41%	9,785,279	5.57%
1990	343,564	-33.86%	41,421,398	0.83%	10,954,017	3.14%
1989	519,456	4.67%	43,624,296	1.19%	10,931,273	4.75%
1988	495,206	- 8.51%	44,689,219	1.11%	11,575,163	4.28%
1987	541,287	-10.68%	45,099,149	1.20%	11,747,595	4.61%
1986	606,037	2.38%	45,940,594	1.32%	13,085,334	4.63%
1985	591,630	- 4.61%	41,632,721	1.42%	12,244,856	4.83%
1984	620,208		36,722,990	1.69%	10,401,511	5.96%

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

TABLE XII

6.3A COMPARISON TO DOD AND NAVY RDT&E

YEAR	6.3a	Increase	DoD RDT&E	6.3a as a % of DoD RDT&E	Navy RDT&E	6.3a as a % of Navy RDT&E
1994	437,354	- 1.41%	34,946,384	1.25%	8,365,786	5.23%
1993	443,592	45.19%	38,975,522	1.14%	9,168,769	4.84%
1992	243,154	- 1.09%	41,286,169	0.59%	9,018,479	2.70%
1991	245,837	20.53%	38,676,994	0.64%	9,785,279	2.51%
1990	195,363	-10.97%	41,421,398	0.47%	10,954,017	1.78%
1989	219,444	-20.29%	43,624,296	0.50%	10,931,273	2.01%
1988	275,307	39.57%	44,689,219	0.62%	11,575,163	2.38%
1987	166,358	-33.03%	45,099,149	0.37%	11,747,595	1.42%
1986	248,420	-15.98%	45,940,594	0.54%	13,085,334	0.54%
1985	295,657	20.18%	41,632,721	0.71%	12,244,856	0.71%
1984	236,004		36,722,990	0.64%	10,401,511	0.64%

Sources: Congressional Budget Appropriations for the fiscal years 1984-1994.

TABLE XIII

BASIC RESEARCH ANALYSIS

YEAR	Budget 6.1	Change	Authorizations 6.1	Change	Appropriations 6.1
1994	433,907	2.65%	445,407	- 6.29%	417,407
1993	486,210	-9.50%	440,009	4.36%	459,196
1992	444,341	-2.70%	432,361	- 0.85%	428,672
1991	434,342	0.00%	434,342	- 1.36%	428,435
1990	437,516	5.52%	461,687	-11.13%	410,308
1989	415,650	0.00%	415,650	- 2.80%	403,999
1988	462,249	-9.08%	420,283	- 1.22%	415,169
1987	489,773	-2.47%	477,676	- 3.58%	460,597
1986	483,233	0.00%	483,233	- 1.61%	475,475
1985	467,689	-0.18%	466,855	- 2.01%	457,480
1984	446,717	0.00%	446,717	0.00%	446,717

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

TABLE XIV

EXPLORATORY DEVELOPMENT

YEAR	Budget 6.2	Change	Authorizations 6.2	Change	Appropriations 6.2
1994	530,119	6.02%	562,019	-16.62%	468,606
1993	639,152	-10.76%	570,397	10.32%	629,271
1992	548,570	4.76%	574,668	- 6.79%	535,658
1991	504,910	7.51%	542,805	0.43%	545,116
1990	461,009	27.91%	589,690	-41.74%	343,564
1989	484,547	0.24%	485,712	6.95%	519,456
1988	558,564	-12.52%	488,653	1.34%	495,206
1987	582,211	- 5.66%	549,274	- 1.45%	541,287
1986	625,931	- 2.56%	609,896	- 0.63%	606,037
1985	637,867	- 5.26%	604,289	- 2.09%	591,630
1984	770,036	-19.46%	620,208	0.00%	620,208

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

Congressional Budget Appropriations for the fiscal years 1984-1994.

TABLE XV

ADVANCED TECHNOLOGY DEVELOPMENT

YEAR	Budget 6.3a	Change	Authorizations 6.3a	Change	Appropriations 6.3a
1994	425,288	- 1.35%	419,527	4.25%	437,354
1993	429,705	-15.60%	362,689	22.31%	443,592
1992	233,017	5.14%	244,992	- 0.75%	243,154
1991	216,116	18.04%	255,094	- 3.63%	245,837
1990	210,739	15.26%	242,888	-19.57%	195,363
1989	237,707	0.74%	239,455	- 8.36%	219,444
1988	313,756	- 0.03%	313,676	-12.23%	275,307
1987	247,225	-20.08%	197,582	-15.80%	166,358
1986	311,296	-10.29%	279,268	-11.05%	248,420
1985	382,324	-31.58%	261,579	13.03%	295,657
1984	290,279	- 8.74%	264,902	-10.91%	236,004

Sources: Presidential Budget Submissions for the fiscal years 1984-1994.

Congressional Budget Authorizations for the fiscal years 1984-1994.

Congressional Budget Appropriations for the fiscal years 1984-1994.

TABLE XVI

ADVANCED TECHNOLOGY DEMONSTRATIONS (CONSTANT)

YEAR	6.3A	ATD	GENERIC	MC ATD
1990	256,639	18,944	18,944	0
1991	221,688	20,510	20,510	5,477
1992	251,002	35,649	18,799	16,850
1993	463,946	55,336	29,311	26,025
1994	425,288	49,535	13,720	35,815

All figures are in thousands of 1994 dollars.

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

TABLE XVII

ATD FUNDING

YEAR	ATD Funding Change	R&D DEMOS Change	MC ATDs Change
1991	8.27%	8.27%	0.00%
1992	73.81%	- 8.34%	207.62%
1993	55.23%	55.92%	54.45%
1994	-10.48%	-53.19%	37.62%

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

TABLE XVIII

ENHANCED TECHNOLOGY DEMONSTRATIONS (CONSTANT)

YEAR	6.3A	ETD	TECH DEMO	ADV ASW
1990	256,639	41,691	41,691	0
1991	221,688	17,619	17,619	0
1992	251,002	53,649	53,649	0
1993	463,946	86,436	9,601	76,836
1994	425,288	100,171	50,999	49,172

All figures are in thousands of 1994 dollars.

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

TABLE XIX

ETD FUNDING

YEAR	ETD	TECH DEMO	ADV ASW
1991	- 57.74%	0.00%	- 57.74%
1992	204.50%	0.00%	204.50%
1993	61.11%	0.00%	43.22%
1994	15.89%	431.21%	- 36.00%

Sources: RDT&E Programs (R-1) Department of Defense Budget for 1990 to 1994.

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